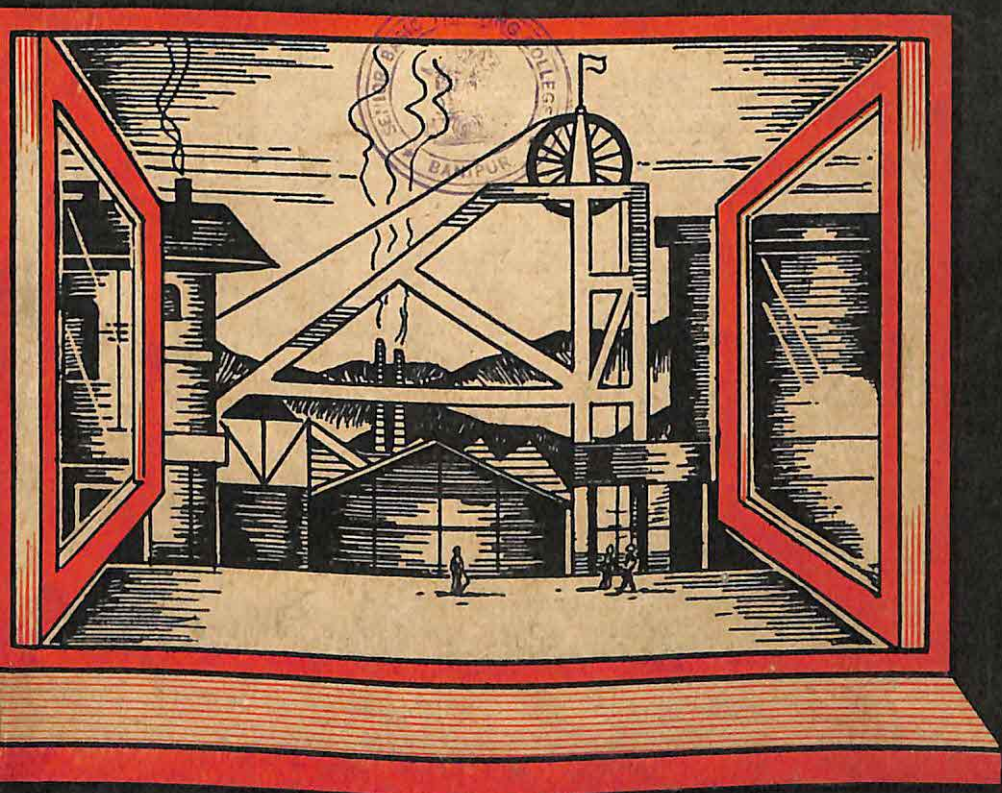


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COAL

by

T. HERDMAN, M.Sc.



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THE COALFIELDS

UNTIL about 250 years ago most people in Britain made a living from the land. The bread they ate came from grain grown in their own fields and the clothes they wore from the wool of their own sheep. Nearly every village had its own craftsmen—a mason, a carpenter and a smith. Towns were few and small. People were most numerous in England in the southern counties where richer soils gave better crops of wheat and conditions suited the raising of sheep. The less prosperous northern counties had few people and these lived in tiny, scattered hamlets.

About the beginning of the eighteenth century a great change began. There were still many people in and around London but new towns sprang up in the Midlands and the North of England and in the Scottish Lowlands. These were unlike the older towns of the south for they had neither their great open market places nor their beautiful churches. Thus in Yorkshire the old cathedral city of York was soon left far behind in size by the growth of Leeds and Bradford and, in the Midlands, Birmingham rapidly out-grew such old cities as Worcester and Lichfield. This was not all, for round the new towns were great straggling villages equally unlike the old villages for they had neither village green nor open common. In such crowded areas farming could neither provide a living for all the people nor all the food they needed. How then did this rapidly growing population make a living and what had caused so great a change?

Several answers could be given to these questions though in the end they all reduce to one. Glasgow people lived by trade—the cotton and sugar and tobacco brought from foreign lands—and by the ships they built to carry it on. Liverpool and London and Hull shared in the same growth. In Birmingham and Leeds and Manchester many factories were built where workers made goods from the raw materials brought to the ports and, through the



Fig. 1. In 1700 most people lived on the good farm lands (shaded on this map).

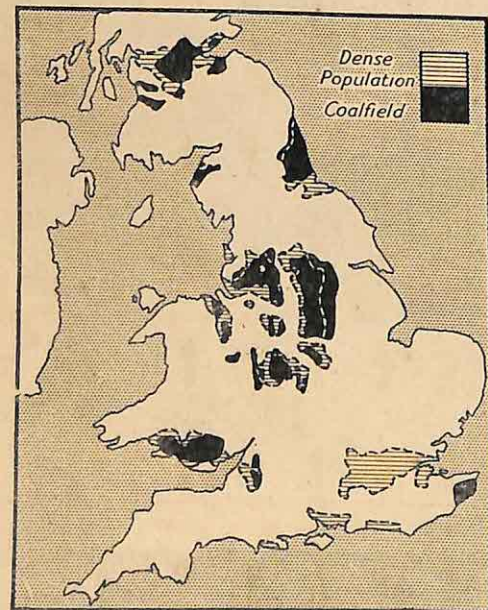


Fig. 2. To-day most people in Britain live in the industrial districts and the great ports.

same ports, sent abroad many of the things they made—clothing and tools and machinery. Thus the growth of factory town and port were connected. It was also through the ports that the new industrial areas secured much of the food the local farmers could no longer supply in sufficient quantity. But the simplest answer to both questions can be given in a single word—COAL.

Watt and Stephenson had shown that the steam engine could do many tasks previously carried out by men and animals and could do them better and more cheaply. And the steam engine needed coal. The districts where this mineral could be obtained from the earth—the coalfields—thus became the homes of many people. The factories which used it were most conveniently placed near the mines. So it came about that the population of Britain grew rapidly, the greater part of it became centred on or near the coalfields, and there it still stays.

What happened in Britain was repeated again when coal was found in other lands. Wherever it could be mined, coal was a great magnet drawing people to work and live near by. Men ceased to be country dwellers and crowded into the mining villages, factory towns and ports.



1850

Country
Dwellers

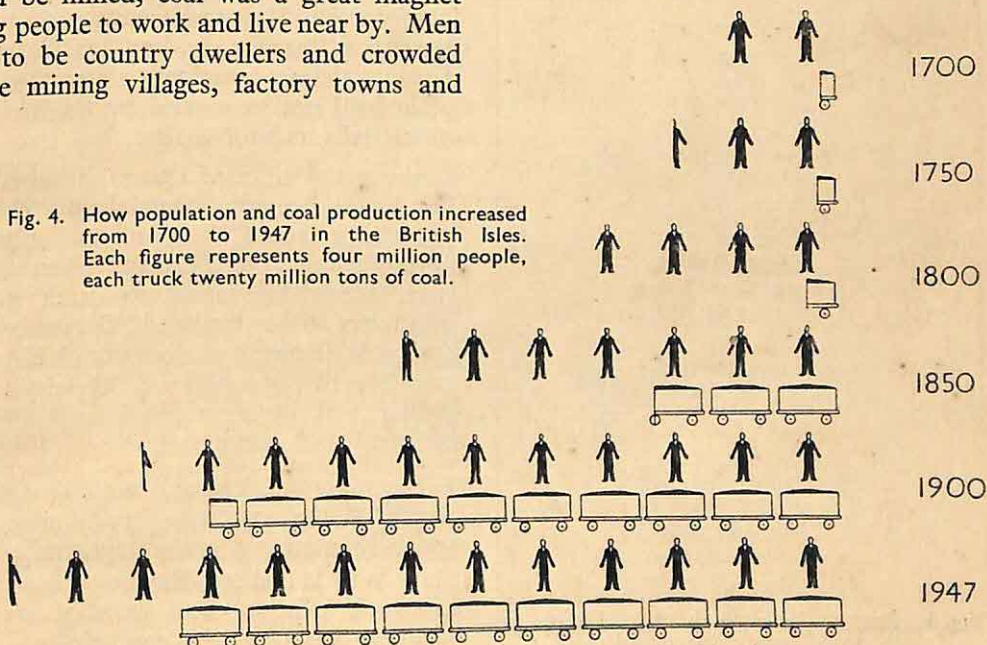
Town
Dwellers



1930

Fig. 3. In 1750, two people out of every ten in England and Wales lived in the towns. By 1930, eight people out of every ten did so.

Fig. 4. How population and coal production increased from 1700 to 1947 in the British Isles. Each figure represents four million people, each truck twenty million tons of coal.



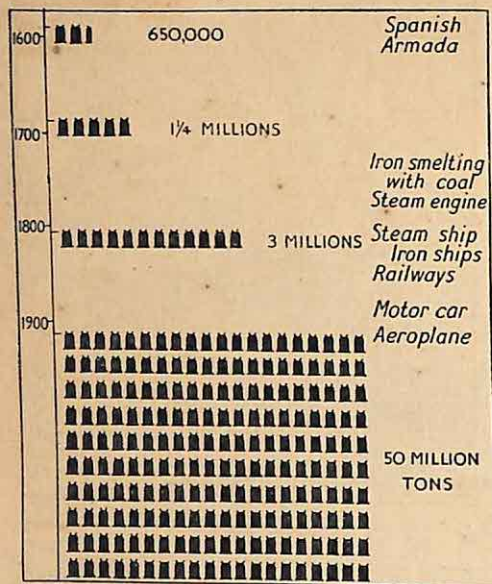


Fig. 5. How one coalfield developed. Each sack represents $\frac{1}{4}$ million tons of coal mined in Northumberland and Durham in one year.

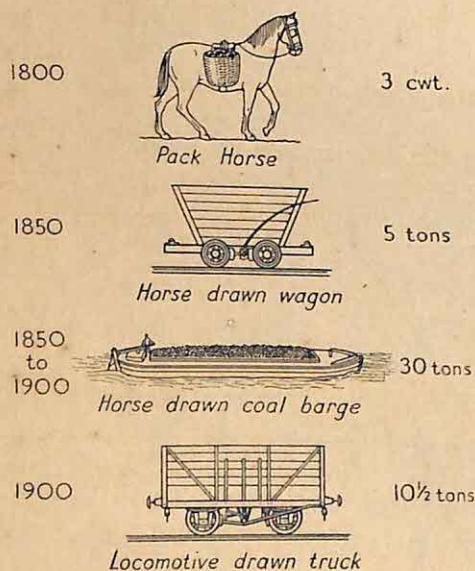


Fig. 6. Progress in methods of coal carrying—increased loads and increased speed.

1 Figure 5 shows how the amount of coal mined in the Northumberland and Durham coalfield increased, over three hundred years, from about 1600 to about 1920. When was the increase most rapid? Can you explain why?

2 In the Middle Ages homes in England were heated and cooking done by means of a wood fire in the middle of the floor. What changes had to be made when coal was used? What changes could be usefully made if our homes were heated by electric fires only?

3 In Britain we use coal for domestic fires, in parts of Canada and Russia wood is used, whilst in many Mediterranean lands charcoal is the usual fuel. How do you explain these differences? What advantages and what disadvantages has each kind of fuel?

4 What do we mean when we say, "That would be like carrying coals to Newcastle"? How do you think this expression arose?

5 Figure 6 shows the chief changes in the means of carrying coal from the mine to the factory town. How many packhorses would be needed to carry a modern truckload? How many to deliver your winter's supply of coal? What load can be carried by the motor lorry which delivers your coal?

6 About the time of Queen Elizabeth many Londoners began to complain of "the stench of burning seacoal" and said its "sulphureous fumes" would spread disease. Even a hundred years later a "fine-nosed city dame" grumbled in a letter to her husband "Oh husband, wee shall never be well, wee nor our children, while wee live in the smell of this city's seacoal smoke". Write the rest of her grumble and her husband's reply to it.

7 The Northumberland and Durham and South Wales coalfields have always been specially interested in the export of coal overseas. Why is this so? Mention some countries to which it is sent and some of the uses to which it is put in these countries.

8 Some countries use nearly all the coal mined within their borders, some have a surplus they can export and others have too little to supply their needs. To which of these groups does each of the following countries belong: Great Britain, France, Belgium, the Netherlands, Poland, Sweden?

9 The lands of the earth where people are most closely crowded are China and Japan, India, Western Europe, Egypt, the eastern United States. In which of these is coalmining carried on? Which would you call industrial lands?

10 Great new coal mines are being opened in Fifeshire in eastern Scotland. The district is at present one of farms and small villages. What changes are likely to follow the sinking of the mines? (Consider the diagram at the foot of the page.)

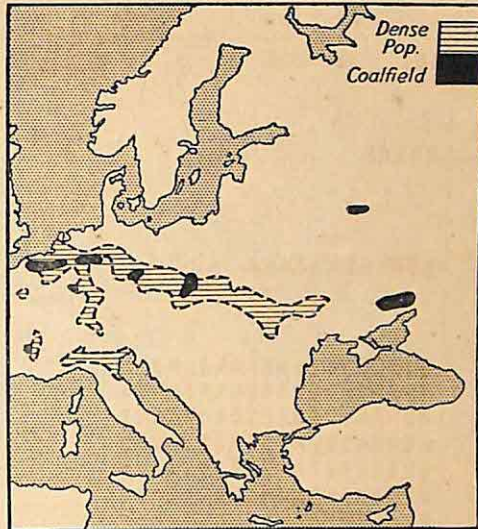


Fig. 7. Coalfields and population in Europe.

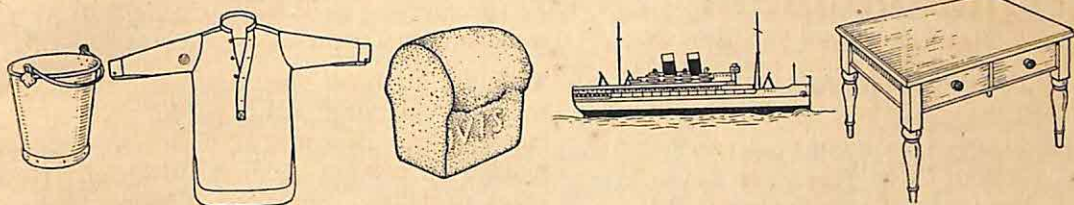


Fig. 8. How did coal help in the making of each of these articles?

11 Explain as fully as you can what is shown by the diagram below.

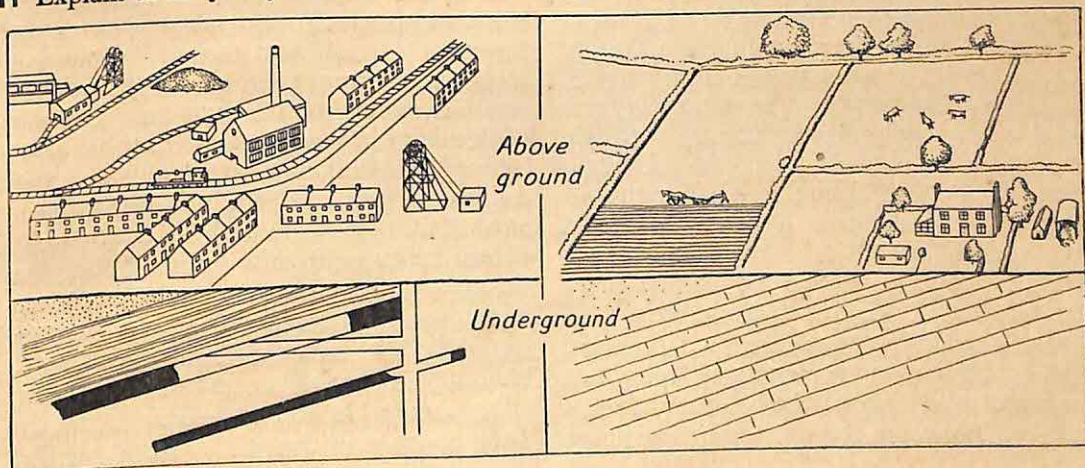


Fig. 9.

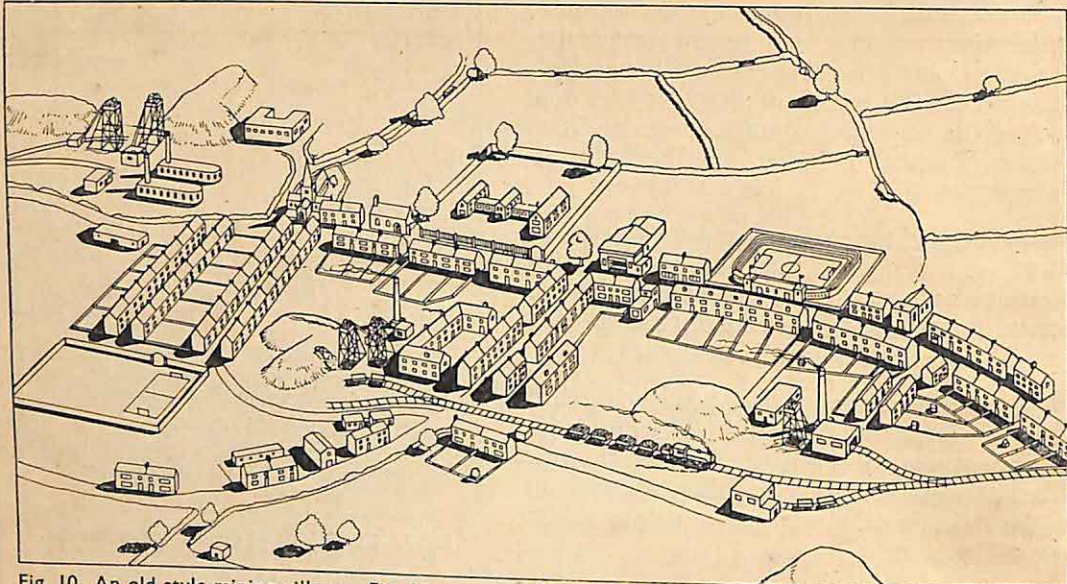


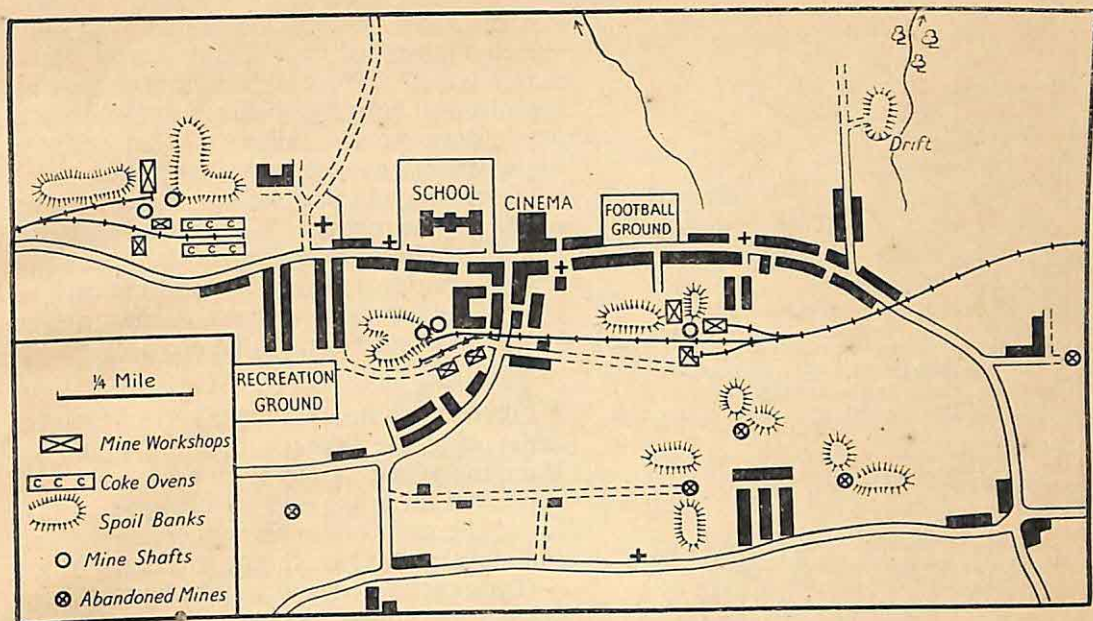
Fig. 10. An old style mining village. Fig. 11 opposite is a map of the same village. Identify the chief buildings on both picture and map. How many mines are there to-day? How many houses are there?

THE MINING VILLAGE

IT is easy to visit one of our coalfields and see how the miner lives, for every one of our great railway systems passes through at least one coalfield and the mining districts are crossed by many branch lines. On all these lines and in the adjoining sidings would be seen long rows of trucks full of coal on its way to the great cities and factory towns. From a station on one of the branch lines probably two or three mining villages are within walking distance, each with two or three, or possibly even ten, thousand people. The road from the station to the village may run alongside a railway track and will almost certainly cross two or three such tracks. These are not used by passenger trains. Each leads to a colliery, for it was constructed to carry coal away from the mine and to bring in timber and steel and other materials necessary to the business of coal-mining. Nowhere else will you find so many

railway tracks in such a small space of the countryside. Remember that the first railways were built to carry coal and the first steam locomotive was built by George Stephenson, a colliery engineman.

The position of the mine is apparent long before it is reached, for rising high above any nearby buildings towers the great framework which carries the pulley wheels over the mine shaft. Great heaps of stone and earth drawn out from the mine cluster round the shaft and the mine buildings and often rise nearly as high as the pithead gear. The village with its houses and shops lies quite near, especially if the mine has been worked for some time, for it would be built before the days of cheap motor buses. As the miner might have to walk a mile or more underground to his working place he preferred to have his home near the colliery. Nowadays, when new mines are sunk, the villages where the workers live may be some distance away so that the dirt and smoke,



unavoidable in coalmining, may be kept out of the miner's home.

In the older villages the most striking features are the long rows of houses, all of the same pattern and all rather small. Sometimes the houses were built around an open square but the more usual arrangement was in two rows facing one another and at right angles to the main road or street. Each pair would be separated from the next by a wide space in which each cottage had its garden. As we shall see, many of the miners have some daylight hours at home and often spend them in growing vegetables for the family or in caring for pets kept in this garden space. Flower and vegetable shows are popular and there is often much rivalry in raising and training racing pigeons, breeding poultry or dogs or canaries, as well as in growing garden produce.

There are few large buildings—a school, a church or two, two or three inns and perhaps a cinema will be the main ones. The visitor will look in vain for the ancient

church or market hall or castle for even the oldest of these villages has been built in the last hundred years or so. A football ground one can be pretty sure of finding. In recent years institutes or clubs have been provided in nearly every mining centre and here the workers gather to discuss the news or play indoor games. A bowling green and tennis courts and a playing space for the children often adjoin the institute and are cared for by its ruling committee.

Old mines, no longer worked and with their spoilbanks becoming overgrown with grass, will almost certainly be found near by. They were abandoned and replaced by bigger mines equipped to reach the deeper coal seams and to extract the coal and treat it more cheaply than was possible in the old days. In the hilly districts a drift or adit mine may be found, that is a mine without any shaft at all and where the miner simply walks into a tunnel in the hillside to reach his working place. Narrow tubways lead from there to its railway in the valley below.

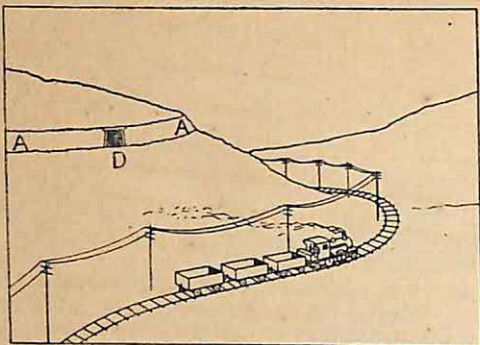


Fig. 12. AA shows where the coal seam outcrops, i.e. comes to the surface.



Fig. 13. This is the upper part of the poster.

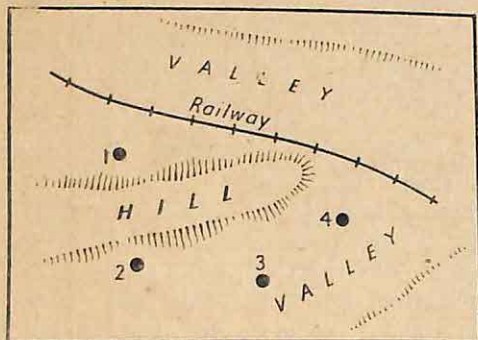


Fig. 14. 1, 2, 3 and 4 are the positions of the mines referred to in Exercise 4.

1 A coal seam outcrops at AA on a steep hillside and is worked by a drift or tunnel whose mouth is at D. The coal is to be sent away by the railway in the valley below. How would you get it down to the railway? What addition would you make to the railway tracks? Remember (i) the railway must be kept clear for other traffic; (ii) the tubs used in the mine hold half a ton, the railway trucks more than ten tons; (iii) empty tubs must be got into the drift as well as full tubs out; (iv) the coal must not be broken any more than can be avoided.

2 Figure 13 shows the upper part of a poster announcing the Miners' Sports Meeting at Hampton village. Copy it on a large sheet of paper and fill in the rest of your space with a list of the main events for young and old and add any sketches you think suitable for it.

If you prefer it, draw instead a poster for the village show of pets, garden produce and handicrafts to be held in September.

3 The mining village shown on page 8 might house 300-400 miners and their families. A single modern mine may employ 2000 or more workers. What difference would you therefore expect to find in the houses and other buildings of the modern mining village?

4 Figure 14 shows the position of four coal mines and a main line railway by which their coal is to be sent away. Copy the map and sketch what you think the best arrangement of mineral tracks to get the coal from the pits to the railway.

5 Mining began with shallow pits, employing few men, in western Durham. It spread eastwards with the opening of larger and deeper pits. The western part of the coalfield is hillier than the eastern.

What evidence can you find on the map on the opposite page for these statements?

6 Make from an old carton an open box with all its edges 1 foot long. This will hold 1 cubic foot. A lump of coal of this size would weigh a little more than 80 lb. (a) How does this compare with your own weight?

If broken up into cobbles or nuts a cubic foot of coal would fill three good-sized buckets. For each man employed at a colliery about 2,400 lb. of coal is produced every shift. (b) How many buckets would that fill?

For every man working at the coal face the weight produced is about 6,400 lb. (c) How many buckets is that?

(d) Can you work out roughly what fraction of the men employed about a pit actually get the coal?

Find out how much coal is allowed for your home in the winter months. (e) How many men work one shift to produce it?

7 The narrow streets of old towns are a hindrance to modern traffic. What reason does this suggest for the abandoning of old mines and sinking of new shafts as shown in Figure 15?

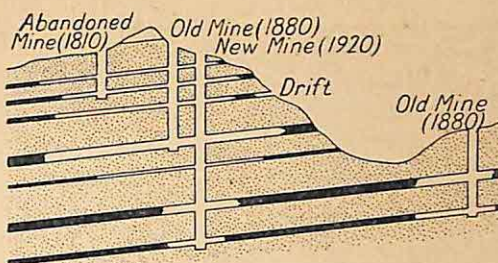
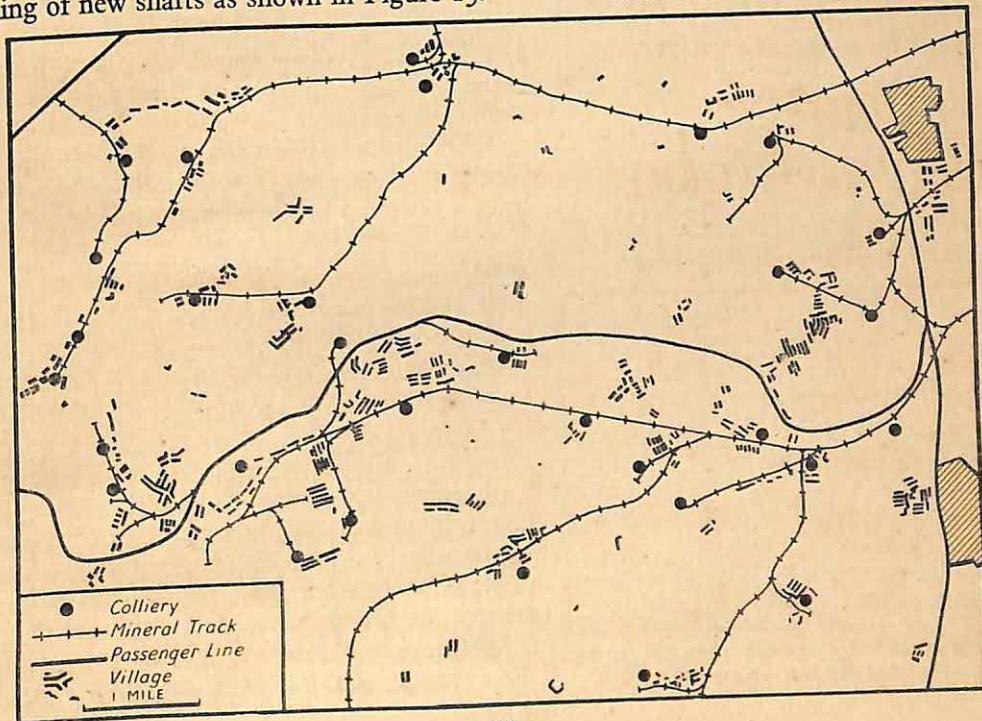


Fig. 15. Mine shafts in an old coalfield. The new mine reaches all the seams. The old shafts may still be of use as alternative ways into the workings for use in case of accident. Sometimes men go to and from their working places by these shafts leaving the big new shaft clear for coal haulage.

Fig. 16. The map shows the north-western part of the Durham coalfield. The towns marked are Durham and Chester-le-Street. Note the large crowded mining villages and the small scattered farming hamlets.



WHAT IS COAL?

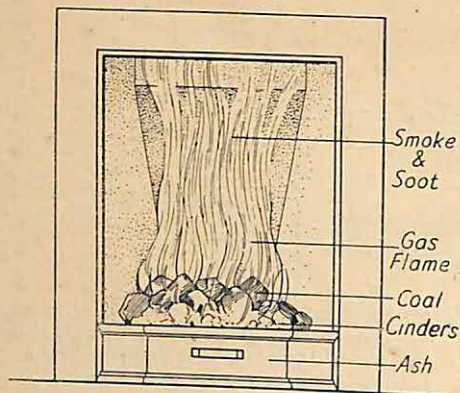


Fig. 17. What happens when coal burns.

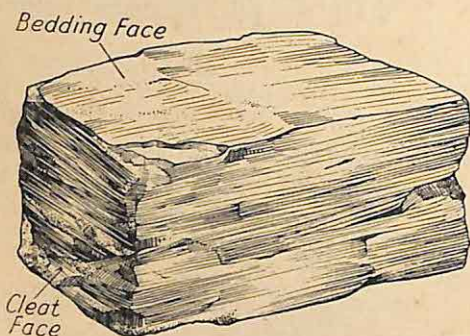


Fig. 18. Bedding face and the two cleft faces.

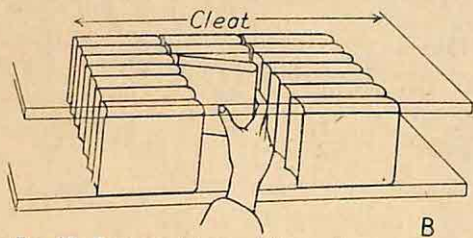
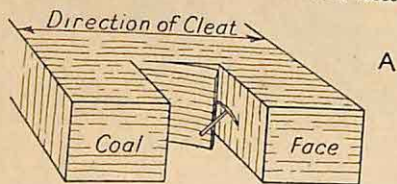


Fig. 19. Easy working and big coal.
How coal is won when the heading is worked across the cleat.

OF all the thousand or more families living in the mining village probably more than nine-tenths are those of workers in the local colliery, the remainder including such folks as the shopkeepers, doctor, teachers, clergymen, innkeepers and the local policeman. Most of the men and the older boys are employed in one way or another in the getting of coal and the rest of the population is there to provide for their needs—all alike depend on coal for their livelihood. What then is this coal?

Nearly seven hundred years ago a famous Italian traveller, Marco Polo, on his return home from China reported that in the north of that country the people were so fond of hot baths that they had burned up all their trees for heating water. So now they used for that purpose "a kind of black stone which they dig out of the mountains where it runs in veins". "This," said he, "when lighted burns like charcoal and retains the fire much better than wood; insomuch that it may be preserved during the night and in the morning be found still burning." Many of his hearers did not believe this story for there was no such stone in their country but Marco Polo was telling the truth and giving a simple answer to our question. Coal is a black stone which burns slowly when lighted. It is found in the ground in some districts and runs in veins or seams amongst the other rocks.

It is not difficult to discover something more about it if one takes the trouble to examine a lump. It is soon seen that it is not all alike. Some is quite dull and powdery and blackens the fingers when handled. Another kind is a very dark grey rather than black in colour, is rather hard to break and splits into thin sheets like roofing slate. Yet another kind is jet-black and shiny but does not soil the fingers when handled and breaks very easily into little blocks rather like a brick in shape. All three kinds can often be found in the same piece, each in a separate layer running through the lump.

The way in which coal breaks is important to the miner, just as the grain of a piece of wood is important to the carpenter. Anyone who has ever chopped firewood knows how much easier it is to split the wood along the grain rather than to break it across the grain. In the same way the miner gets the coal most easily when he works with its grain, or, as he calls it, with the *cleat*. A lump of coal breaks most easily along the bedding, that is into the layers already noticed. That, as will be seen later, is because it was originally formed in sheets one on top of the other. The cleats—for there are two, one clearer than the other—run at right angles to the bedding and form the upright faces of your brick-like piece of broken coal when it is placed so that the bedding is horizontal *i.e.* in the position it occupied when it was lying in the coal seam.

Coal is valuable mainly because it burns readily and gives much heat in doing so. If one watches a burning fire and examines the grate when it has gone out, or heats some broken coal in a tin canister, more can be found out about this burning. The fire gives off smoke which passes up the chimney and leaves there black, powdery soot. Some kinds of coal soften when they burn and boil up into little bubbles which burst with a hissing sound. Little spurts of smoke or steam shoot out and then a jet of flame which burns brightly for a moment. This flame is burning gas set free from the hot coal. Fine grey ash is all that is left of completely burned coal but often there can be found in the dead fire some grey, spongy-looking lumps of cinder or coke. These will still burn if put on the lighted fire. Thus gas, coke, soot and tar are all produced when coal is burned.

The heat of a gas fire, just the same as that of an open coal fire, comes from the burning of coal. The scientist says it is less wasteful. Who does the dirty tasks the housewife escapes? What are some of the things saved?

On page 64 you will find an index. Use it to find out more about gas.

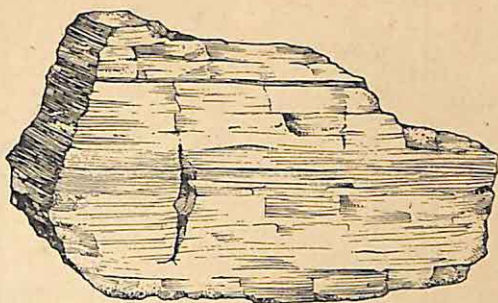


Fig. 20. A lump of coal—

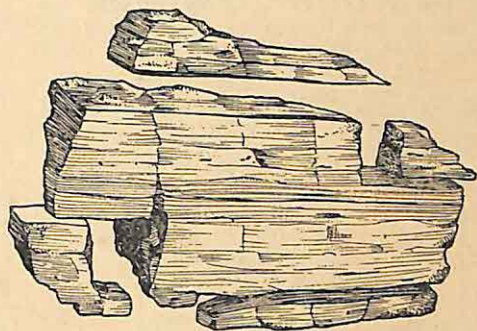


Fig. 21. and the pieces into which it broke.

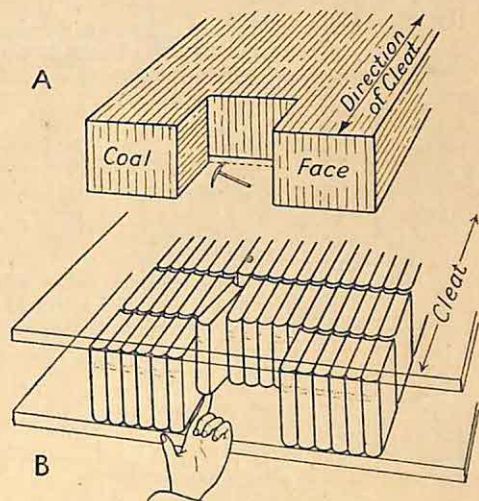


Fig. 22. Difficult working and much small coal. How coal is won when the heading is worked along the cleat.

HOW COAL WAS FORMED

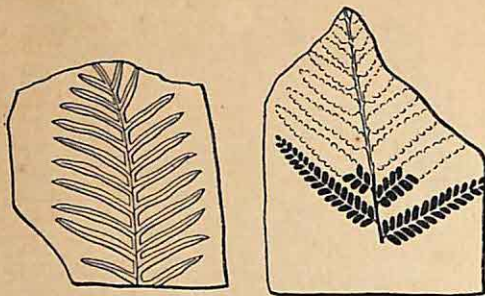


Fig. 23. Impressions of fern leaves on shales from the coal measures. In the example on the right the material in the leaf in its lower part has been changed into coal.

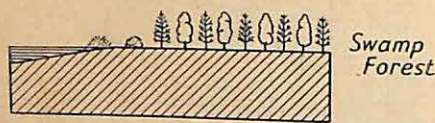
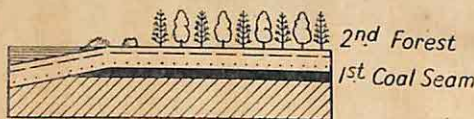


Fig. 24. Stages in the formation of two coal seams:
(a) The forest and its undergrowth flourish in the wet coastal swamp.



(b) The land has been submerged by the sea, and the vegetation in the forest has begun to change into coal.



(c) The shallow sea has been filled up with mud and a new forest grows in the swampy land many feet above the first coal seam.



(d) The land has again been submerged and the second forest, now buried, begins also to change into coal.

MOST people are aware that coal was formed from plants. But more than that must be known about it if the miner's work is to be understood. Many of the rocks found in the coalfield areas show impressions of leaves and stems and, occasionally, even trunks and roots of great trees have left their traces. Most of these belong to types of vegetation which grow in swampy places in rather hot lands. From evidence such as this the geologist is able to tell us just how coal came to be formed.

Millions of years ago, when the climate of Britain was much warmer than it is to-day, great swamps covered much of the land, just as they do now in the great deltas of the Ganges and the Niger. Immense forests spread over the rather drier parts and the shallow pools were full of reeds and other water-loving plants. Year by year the older trees and plants died and new ones grew in their places. After a long time floods covered the swamp and the decaying trees on its surface. They swept in sands and mud which covered all the old forest floor. Again for many years layer after layer of these accumulated until the water became shallow enough for reeds and then trees to begin growing again. Once more the forest spread and again after many more years it was killed by floods and another layer of rotting leaves and wood was covered with sand and mud. It was these accumulations of dead vegetation which in time came to form the coal seams of to-day. Buried deep beneath the rocks formed in the long ages that have passed since the coal forests grew, the peaty mass of decaying reeds and leaves and stems has very slowly changed into the black mineral we call coal.

Now can be seen the answers to many questions about coal and coalfields that at first seem puzzling. Why have some countries got plenty of coal and others none? Because not all the lands had swampy forests. Even in the coal age some lands had great deserts like the Sahara

and some, like the high mountains and polar lands of to-day, were too cold for forests to flourish. Why is coal found in great flat sheets covering many square miles? Because the forests from which it was formed grew on flat swampy plains. It is clear too why a succession of coal seams, one above the other, is found in any coalfield and why these vary in thickness from a fraction of an inch to twenty or thirty feet. Every coal seam marks a period when a forest grew—a long period gave a thick seam, a short period a thin one. When the climate was no longer suited to forest growth and the swamp dried up, then the coal age in that region finally came to an end.

The different kinds of coal are the results of differences in the conditions under which the coal was formed. The *peat* of the Irish bogs and the Pennine moors has been but little altered from the dead mosses and heather out of which it was made. It has not been formed long enough or buried deeply enough to have passed into coal. In some lands a brownish kind of coal called *lignite* is found. This has progressed a stage further towards ordinary coal but is still very soft and has the colour of dead wood. Some coals, on the other hand, have been buried so deeply and had such great pressures put upon them that they have changed into the fuel known as *anthracite*. At each step in the change the carbon of the original plants remains—and most of the heat from burning fuel comes from this carbon—but the other constituents which form the smoke, tar and gas disappear. Thus anthracite is almost smokeless and burns without a flame, whilst peat and lignite are very smoky fuels. In the gas works soft coal is heated to drive off the gas and the coke remaining is like anthracite in that it consists almost entirely of carbon and ash. The diagram shows how the proportion of carbon increases as we pass from wood to anthracite.

The common types of coal in this country are often called *bituminous* coals because they all yield tar when heated. Such are gas coals, coking coals and steam coals.

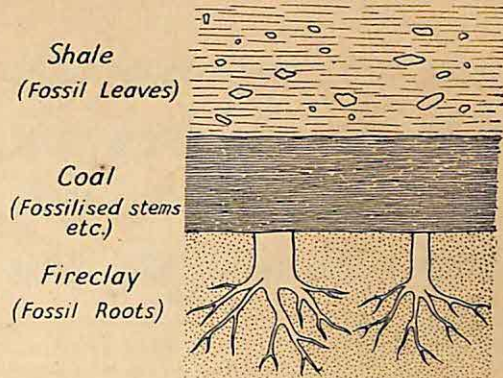


Fig. 25. The roots are still in place in the soil in which they grew, the surface vegetation forms the coal seam and stray leaves are found in the mud which covered the forest.

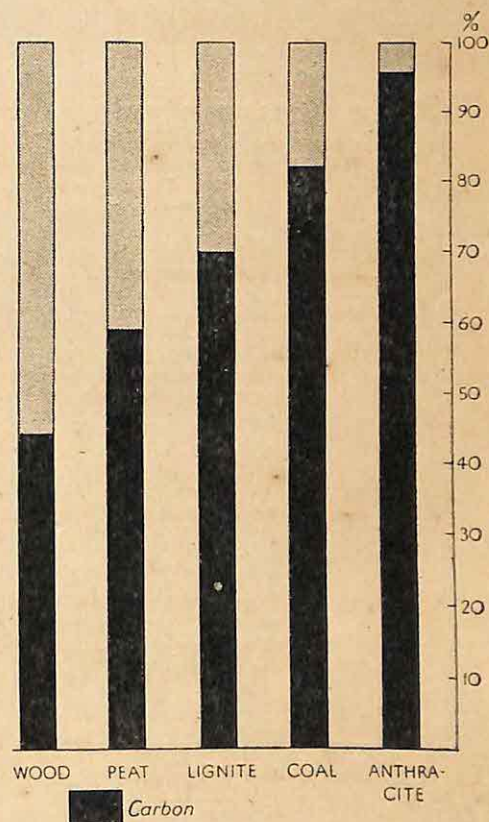


Fig. 26. How the carbon percentage increases from wood to anthracite.

For every 22 trucks sent to London

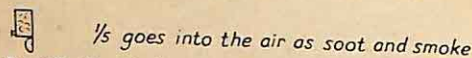
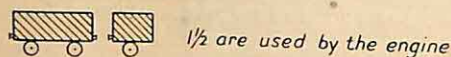
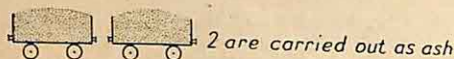
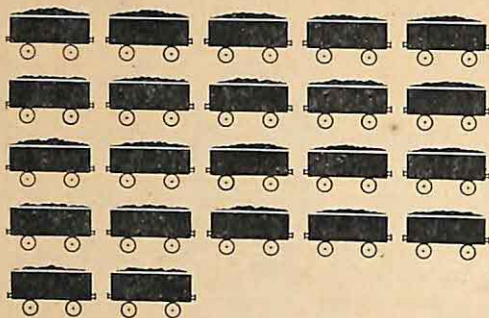


Fig. 27. The Coal goes to London from Yorkshire.

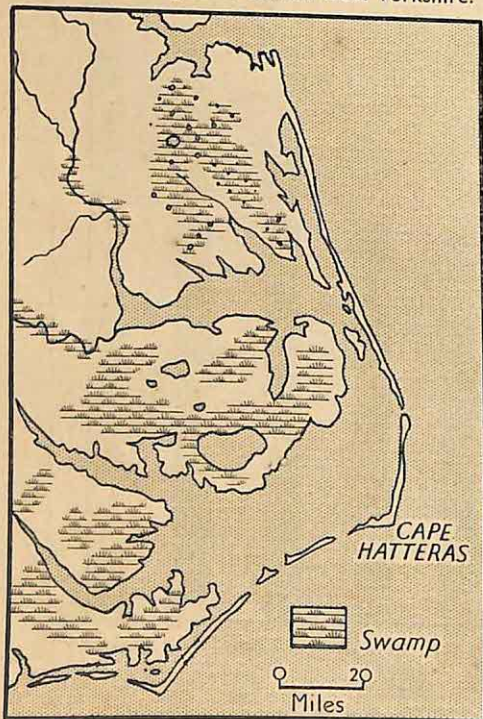


Fig. 28. A coastal swamp in the United States.

1 Figure 27 shows that about one-seventh of the coal mined in Yorkshire and sent to be used in London is wasted in smoke and ash and in getting it there. Very little waste of these kinds occurs when gas is conducted in pipes or electricity by cables, unless the distance is very great.

What does this suggest as possibly the best places in which to build gasworks and electric power stations?

2 When goods are carried by ship or rail the charges made depend on their weight. With all kinds of coal some of the money thus paid is wasted, for the weight paid for includes that of the ash and other waste in the coal. Is this waste greater for coal or for peat? for lignite or for anthracite?

How does this help to explain that in recent years we have sometimes brought coal from the United States to England when there was a great deal of unused peat available in Ireland and in the Scottish Highlands, and that it has been worth while to send anthracite from South Wales to Canada?

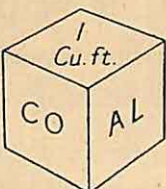
3 Coal is mined in the island of Spitsbergen, 1500 miles north of Scotland, though the seas around are frozen over for much of the year. When Captain Scott's expedition went to the South Pole it found coal seams in a few places. What does this tell us about the climate of the Polar lands in past ages?

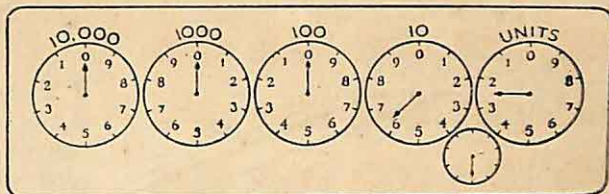
4 Conditions like those in which the coal forests grew can be found in a few coastal districts and in great river deltas in hot lands. Find from your atlas the names of rivers with such deltas.

5 As Marco Polo found, there is much coal in China. Italy still buys abroad most of the coal her factories use. Can you now suggest an explanation of these two facts?

6 An explorer in Canada comes on a place where he thinks Indians had camped shortly before. What would be the best evidence he could find to prove this?

How do we know that the Romans sometimes burned coal when they were in Britain?

THIS  MAKES
62.5
Units



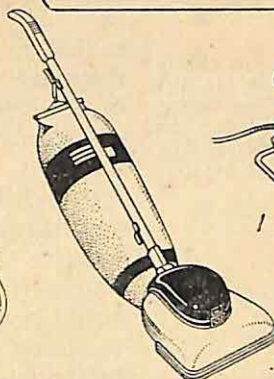
THESE USE
EVERY HOUR



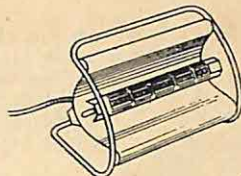
.08 Unit



.06 to 1 Units



.36 Unit



1 Unit



.75 Unit

Fig. 29. Three buckets of coal (1 cubic foot) make about 62.5 units of electricity. The diagram shows some of the ways in which this is consumed in our homes and the amounts used by each in one hour. Few domestic lamps use more than 0.25 units. Can you read correctly the electricity meter?

7 A small one-bar electric fire uses 1 kilowatt of electricity per hour. A cubic foot of coal gives about 60 kilowatt hours of electricity. If you have an electric fire at home find how much it consumes and for how many hours it is burning in a week. How many buckets of coal are used in this way in your home in a week?

8 Some of London's largest power stations are built by the river side. Why is this? From what coalfields in Britain can they be most easily supplied?

9 Smoke and soot from city chimneys is not only evidence of money wasted in buying coal but also causes much waste of labour. Mention some of the ways in which this occurs.

10 Traces of other things besides leaves and stems are found in rocks associated with coal seams. Which of the following do you think might be found? Fishes. Boats. Knives. Insects. Worms. Birds. Shells of animals.



Fig. 30. Fossil tree stems in a sandstone quarry in South Wales. The trunks stand as they did when the sands of the ancient seashore swept over them long ago.

HOW COAL IS FOUND

(i) THE GEOLOGIST SUGGESTS

IN the millions of years which have passed since the coal forests grew and were buried many things have happened to the crust of the earth and have affected the coal beds. Other beds of rock have been formed on the surface so that in some areas the seams are now buried thousands of feet deep. In many districts the beds of rock have been disturbed and pushed into great waves or folds. In all districts the surface is being constantly worn away and destroyed by weather and by streams. In this way many difficulties have arisen for the mining engineer. How is he to know where to sink his mine? How can he be sure that when he has sunk it he will find coal enough to pay him for his trouble? A new Scottish mine has to be sunk 3,000 feet and will cost over £2,000,000 before any coal is got!

The map of part of western Europe will help to answer these questions. The geologist from his study of the rocks of these countries can tell within what districts the coal forests probably grew and these are shown on the map. Even within this area however one cannot be sure of finding coal nor of finding enough to make mining worth while. Some parts of it are deep beneath the sea. In others the rocks in which the coal seams occurred, called the *coal measures*, have been destroyed and their coal with them. In yet others the forests were so scanty that the coal seams are too few and thin to be worth working. The valuable coalfields are only a small part of the ancient forest areas.

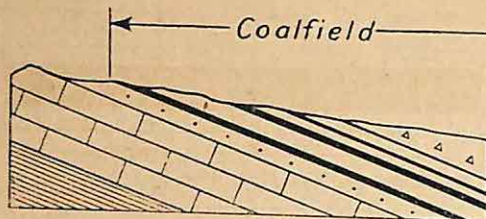


Fig. 31. A Dip coalfield. One boundary is clearly where the lowest seam comes to the surface on the left but only deep boring can discover the opposite boundary on the right. The English coalfields on the flanks of the Pennines are of this type.

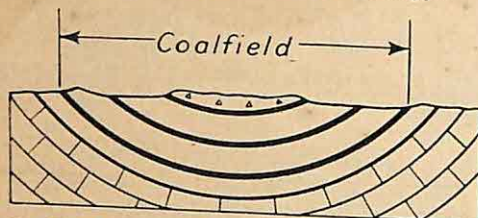
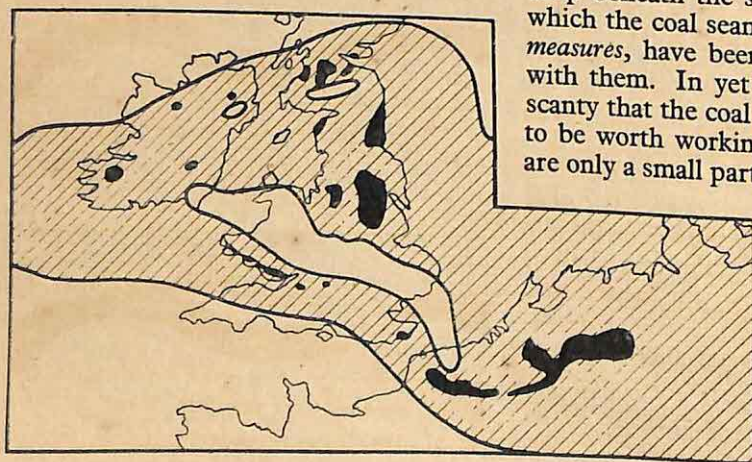


Fig. 32. A Basin coalfield. The coal seams all come to the surface around the margins of the field. Its boundaries are therefore known from the beginning. The South Wales coalfield is of this type.

Fig. 33. The areas in north-west Europe where forests probably grew and the areas where coal is found and is being mined to-day.



Figs. *a, b, c, d, e*, show what has happened in some British coalfields: (*a*) shows the coal-seams newly formed and lying undisturbed amidst the other beds; (*b*) shows the effect of folding on these rocks; in (*c*) is shown what was left after rain, snow, wind and rivers had, over a long period, broken up and removed much of the surface rock; (*d*) shows how new beds of rock were then laid down and covered the old worn surface and its underlying beds; (*e*) shows the present position when a great river valley has been cut through all the new rocks right down to the coal measures. Clearly it would be foolish to sink a pit in the bottom of the valley at A for the rocks there are older than the coal seams. On the other hand the coal-bearing rocks come to the surface on the valley slopes and the position and thickness of the seams could easily be discovered by digging away the surface soil. The coal here could be worked by drifts tunnelled into the hillside. It would soon become clear whether the seams were lying horizontally or sloping in a particular direction. This information would make it possible to guess how deep a mine sunk, at B say, would need to be and how many seams would be met and of what thickness.

In some coalfields, such as the South Yorkshire and the Northumberland and Durham, the coal seams slope (or *dip*) fairly regularly in the same direction. They come to the surface in the west of the field but pass more and more deeply underground towards the east. Thus the oldest mines, many of them now worked out and abandoned, were opened in the western districts. The new pits are on the eastern side and are far deeper than the old ones. In other fields, such as South Wales, the seams lie in a trough or basin formation. The old shallow pits are found on the edge, the newer and deeper shafts in the middle.

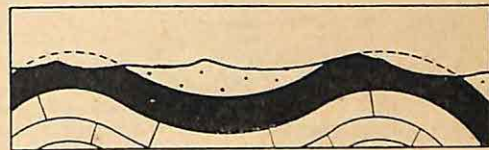
The seams of the great Appalachian coalfield in the United States are nearly horizontal and crop out on the slopes of the deep river valleys. They are therefore very easy and cheap to work.



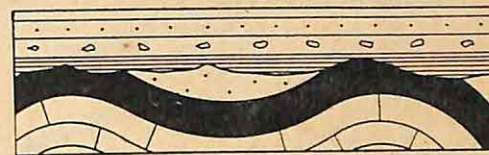
(a) Undisturbed coal seam.



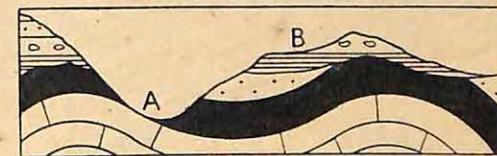
(b) The rocks are folded,



(c) and much of the surface removed.



(d) New beds of rock are laid down,



(e) and these again are partly destroyed.

Fig. 34. The Geological History of a Coalfield.

HOW COAL IS FOUND

(ii) THE BOREHOLE PROVES

TO make sure that coal is present and to find out how many seams there are, of what thickness and at what depths, the mining engineer sinks a borehole. This is really a tiny shaft, only a few inches in diameter. It is made by driving a heavy steel chisel through the rock. Really it soon drives its own way for it is simply lifted and dropped repeatedly with a part turn round after each drop. As it drills its way underground a length of steel rod is screwed to its upper end and then others one after another, until the whole chisel is hundreds of feet long. The dusty powdered rock works out at the surface so that the engineer in charge has a rough idea of the kind of rock being cut through at any time. To get more accurate information the chisel is withdrawn and replaced by a round scoop or sludger with which a sample of the broken rock at the bottom of the hole can be obtained for examination. From these samples and by measuring the length of rod used the engineer can determine the depths at which the chisel has cut the coal seams.

This simple old method has now often been replaced by one which enables more accurate information to be obtained and holes to be cut to far greater depths and much more quickly. This new way is very like that used by the gardener when he wishes to plant bulbs in a grass plot. He presses a sharp-edged tin into the surface with a screwing motion (*i.e.* as though it were a screwdriver) until it has penetrated three or four inches. If it is then carefully withdrawn it will lift out a core of turf and soil which can be shaken out of the tin and replaced when the bulbs have been placed in the hole. In sinking a deep borehole the place of the gardener's tin is taken by a heavy hollow metal cylinder with tiny diamonds fixed round its lower edge. This cuts

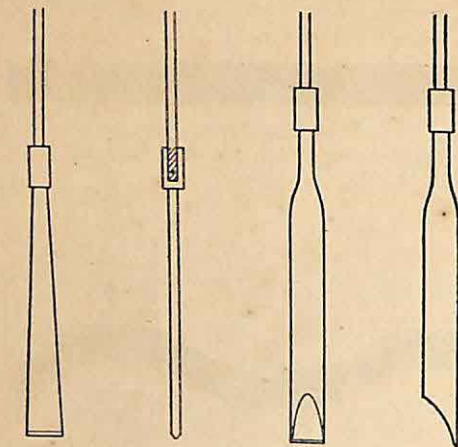


Fig. 35. Old type boring tools. Side and front views of a chisel on the left, and a sludger on the right. Why is the chisel edge the widest part of the tool?

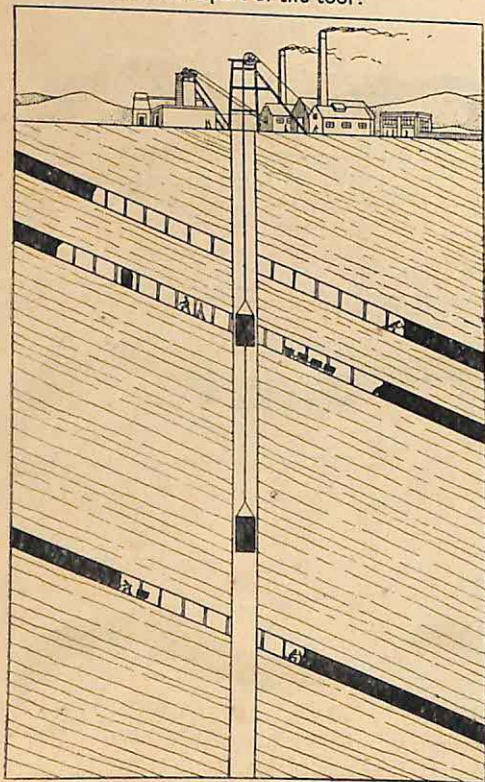


Fig. 36. Old style mining. The roadways follow the seams and are therefore often steep and low.

through the rock as it is rotated and when withdrawn from the borehole brings with it a core of unbroken rock which can be measured and examined. As the drill head cuts deeper and deeper into the earth, lengths of strong steel tubing are screwed to the upper end to lengthen it. A small engine at the surface keeps the whole drill rotating and also applies the pressure needed to keep it cutting. Boreholes over a mile deep can be cut in this way.

When the engineer knows that he will not reach coal for some hundreds of feet he often replaces the diamond drill by one armed with strong steel teeth. Water is forced down the tube and washes the powdered rock outside the tubes to the surface. This softens the surface where the drill is cutting and keeps the latter from becoming too hot. When the level of the coal seams is nearly reached the diamond drill is fitted and its cores examined. In this way the engineer can get all the information he wants whilst reducing the amount of expensive diamond drilling to be done.

If a big area is to be worked and little is known of the beds in the neighbourhood three or four boreholes may be sunk before it is decided just where to place the main shaft of the mine.

OLD AND NEW STYLE MINING

In the old type of mine the workings usually started from the point where the shaft cut the seam and followed it, even when it sloped steeply. If the seam was thin, only small tubs could be used and it might be necessary to cut away rock from the roof or the floor. In the new mines the main roads are cut horizontally and if the seams are inclined these are reached by short vertical shafts. The roadways are made high enough for large coal-carrying cars, drawn by engines, to be used to bring the coal to the shafts.

Fig. 38. Modern type boring. The upper drawings show how you can use a tin as a boring tool to lift out a core of turf and soil. The lower drawing shows how the diamonds are arranged around the head of a modern boring drill.

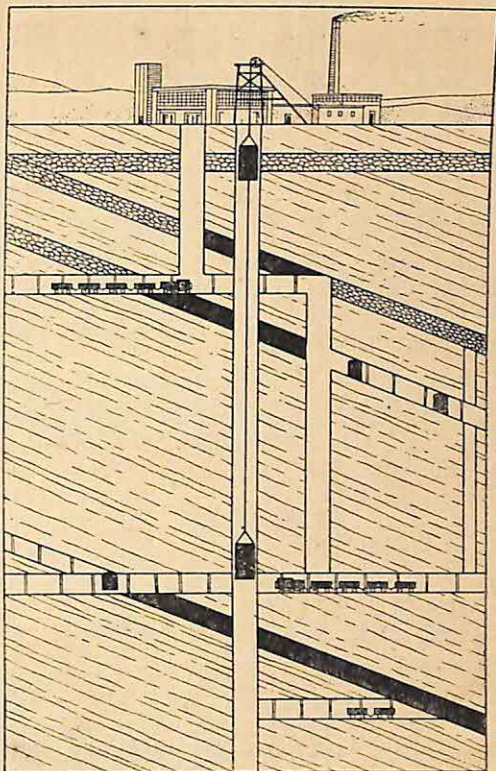
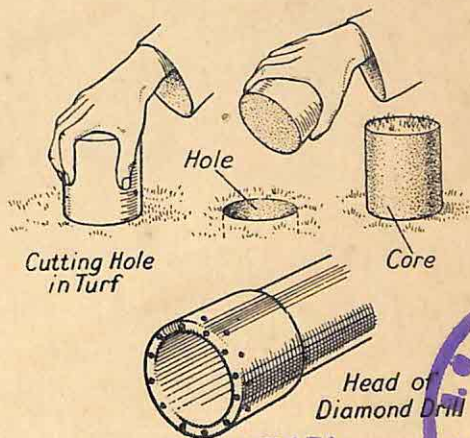


Fig. 37. New style mining. The main roadways are made high enough and level enough for tubs to be drawn by locomotives.



SINKING THE MINE SHAFT

BOB ELLIOTT lives in a mining village and is going to work in the local colliery when he leaves school. He will take us round to see one of his grandfathers who worked in coal mines till he was over seventy years old and now lives in a cottage just outside the village. We found the old man busy in his garden but very ready to sit down and talk about the pitmen he had known. Everyone calls him "Sinker Joe" and we soon learned the reason for this. Here is his story:

"Some folk would not think me much of a pitman for I hardly dug a bucket of coal in thirty years. All the same, not much coal would have been got in this countryside without the work my mates and I did. We were the chaps that sunk the pits and that's why the neighbours still call me Sinker Joe. I started on the job when I was twenty-five, a big strapping chap that'd already had a dozen years in the pits. Shaft sinking is a job for strong active chaps—I've climbed a hundred feet up the timber framework in a shaft more than once when things have gone a bit wrong—but they need to know the ways of rocks too and there's no place like the pit for learning that. There have been lots of changes in the job since I first started at it but I can tell you how we tackled it.

"The engineers picked the place for the shaft and got things ready for our gang to start. You see we used to work in a team and go from place to place wherever there was a sinking to do. They'd have got the ground levelled and a big circle marked out, maybe twenty feet or more across. Up above they'd have a strong wooden framework with a pulley wheel and an engine close by to draw up the kibble as the shaft deepened. The kibble was just a sort of big steel bucket, big enough for a couple of men to stand in it. They'd have a little railway track laid to carry away to the dump the stones and dirt as we dug them out. In the old days we'd have had a horse gin to draw up the kibble.

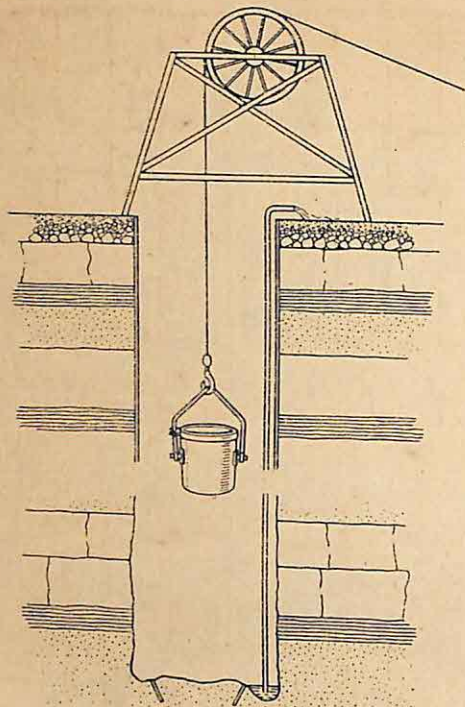


Fig. 39. The first stages of shaft sinking. The simple temporary pit-head gear will be used while the permanent gear is being erected. Describe the kibble. What will take its place when the shaft is finished?

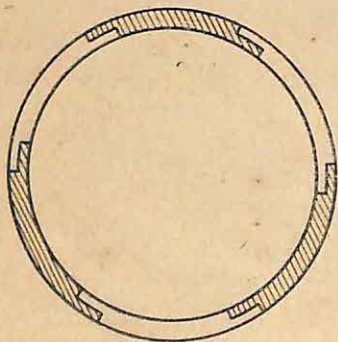


Fig. 40. How the iron casing of a shaft is fitted.

Bob knows where there's still one of them by the old Daisy Pit.

"When we started work we soon got down to the solid rock. Sometimes we could get that out with picks but often it was so hard we had to blast it. With long chisels and heavy hammers we'd drill a lot of holes, maybe a yard deep, all round the edge of the shaft and pack a charge of gunpowder into each. Then when everyone had got out to the surface these would be exploded. Back we went and loaded the broken stuff into the kibble and away it went up the shaft and off to the dump. We'd all got to be careful for it was dangerous work. There was always the risk of bits of rock falling on you, so we were glad when the shaftmen followed us up and lined the walls with timber or brickwork or strong steel sheets.

"It may sound queer but I've known men nearly drowned before they could get out of the shaft. After all a pit's only a kind of big well and the water in the rocks soon drains into it. Before we got very far down we had to have a pump fixed to get rid of it. Bob's granny had some very wet and muddy clothes to deal with in those days. I know some pits where they had to freeze the water in the rock to hold it back till they could get deep enough to fix a steel lining to keep it out.

"Another two of our troubles were the heat and the air. The farther down you go the hotter it gets and for weeks I've worked with nothing on but a pair of shorts and my boots. The air got very bad too and in a deep sinking they had to fix up a blower to drive fresh cool air down to where we were working.

"Well, that's the sort of job I did for nigh forty years. I never worked in a shaft more than a couple of hundred fathoms deep—that job took us nearly three years! With all their new machinery it must still be tough work, now they go down to five hundred. I've heard these new Scottish pits will be 3,000 feet deep and they reckon to put them down inside two years—that's four times as fast as we could do it."

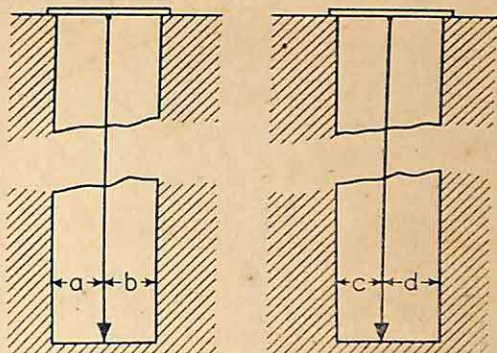


Fig. 41. Is the shaft vertical? Can you tell from this diagram how the sinker checks it?

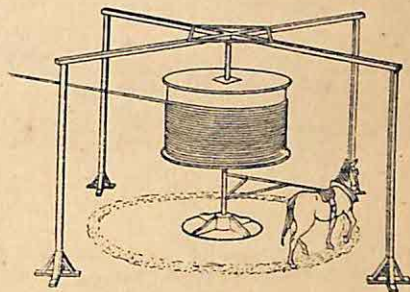


Fig. 42. An early method of cage haulage—the horse gin. Is the cage being raised or lowered in this picture?

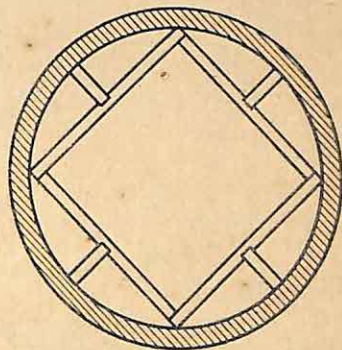


Fig. 43. Plan of timber or steel framing in the shaft.

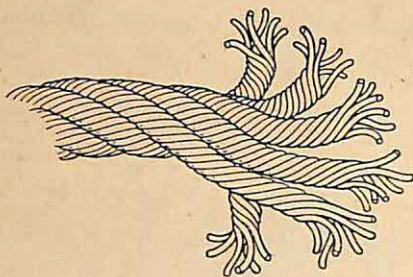


Fig. 44. How a wire haulage rope is built up.

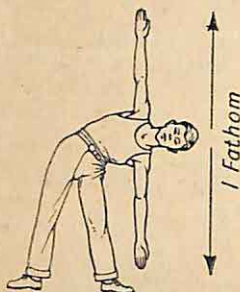


Fig. 45. How the fathom originated.

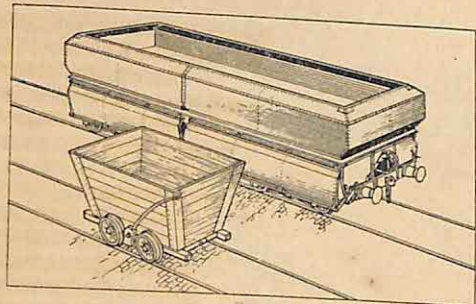


Fig. 46. Early wooden coal wagon alongside the latest type of steel wagon.

1 A haulage rope consists of six sections twisted together, each section containing thirty-seven strands of wire. How many *miles* of wire are needed to make each hundred yards of rope?

2 The pitman, like the sailor, measures depths in fathoms. A fathom was originally the depth which could just be spanned between finger tips with one arm outstretched upwards and the other downwards. How many feet deep is the 500 fathom shaft? Compare your arm stretch with your own height and with a fathom.

3 Out of every pound earned by British Railways in 1947, 11s. 2d. came from passenger fares and parcels traffic, 5s. 7½d. from goods traffic and 3s. 2½d. from coal carrying. They spent thirty-six million pounds in buying coal for their own use. From what districts was the coal carried and to what cities would much of it go?

4 The Northern Region, London Midland Region and Western Region railways are all important coal carriers. Consult your atlas and discover (a) which coalfields each serves; (b) to what places each carries much of this coal. Remember that a good deal is used for gas-works and power stations, much for factories and some for export.

5 The graph opposite shows how coal traffic on what was formerly the L.M.S. varied from 1924 to 1945. Why was it lower than usual in 1926 and again in 1932-3? Why was it high in the war years? What happened to it as the war progressed? Why? How do you think it will have varied since in the districts served by the London Midland Region of British Railways?

WHO PAYS FOR THE RAILWAYS

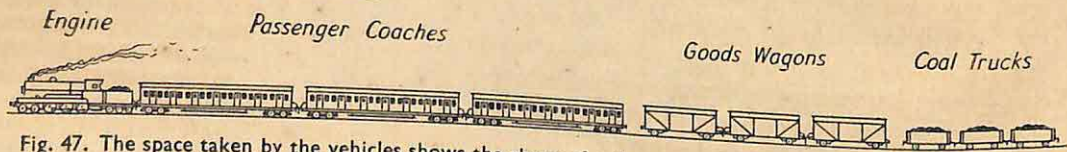


Fig. 47. The space taken by the vehicles shows the share of railway income provided by each sort of traffic.

6 Having considered exercises 3 and 5 write a paragraph explaining why railway officials are particularly interested in the coal trade.

7 Heat some pieces of coal in a clean tin. Describe what happens and what sort of substances are left. Try to fix up some arrangement to collect any gas given off. How is it that gasworks have coke for sale and coke-works have gas for sale?

8 The tubs formerly always used for underground haulage of coal held a half-ton each and for part of the way to the shaft were drawn singly by a pony in charge of a boy. For the rest of the way they were formed into trains of perhaps twenty tubs drawn by a wire rope attached to a stationary engine at the shaft foot. In modern times big cars holding 4 tons and drawn by locomotive engines are used. Which is cheaper to install? Which is cheaper to run? Give the reasons for your answers. Remember (i) some seams are only about 2 ft. thick and some slope quite steeply; (ii) every wheel uses up some power because of stiffness (*i.e.* friction) in its bearings; (iii) heavy trucks need strong rails, well laid on a good foundation; and look again at Figs. 36 and 37 on pages 20 and 21.

9 Why do you think it is important to have the pit shaft truly vertical? How do the sinkers check this?

10 Coal is sometimes spoken of as "Bottled Sunshine" and sometimes as "Black Diamonds". Can you suggest any reasons for these names?

11 Where in your district can you see the rocks that lie below the soil? Make a sketch to show how they are arranged and label the kinds of rock shown.

12 Examine the map on page 18. Name two parts of Great Britain in which coal was never formed and two in which it was probably formed but has since been destroyed.

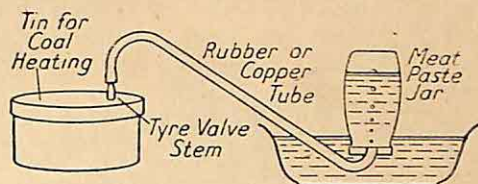


Fig. 48. A simple kind of arrangement to collect gas from heated coal. Why is copper tubing more satisfactory than rubber?

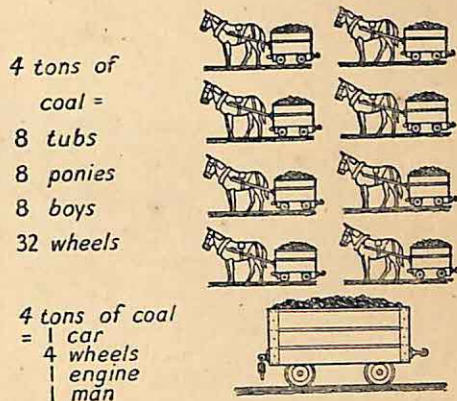


Fig. 49. Which is better: little tubs or big trucks? Can a truck be too large?

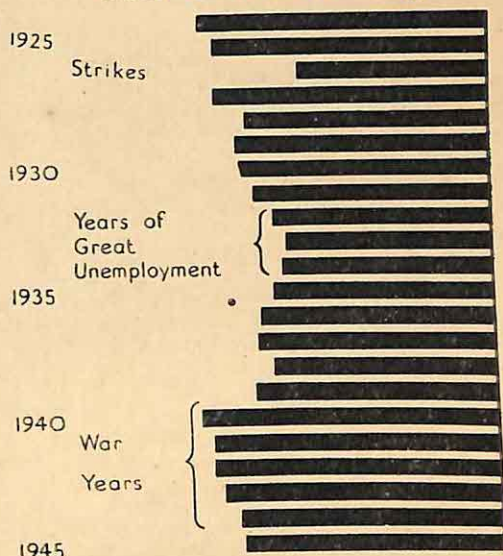


Fig. 50. How coal traffic varies from year to year.

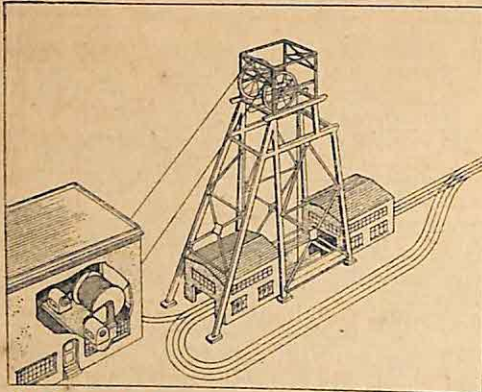


Fig. 51. Pit-head gear and winding engine.

HOW THE SHAFTS ARE USED

THE shafts are the main gateways to the mine. Through them passes every person and everything that enters or leaves the pit—the people who work in it, any animals they employ, the tools and supplies of every kind that are needed, the coal that is won and the rock waste that cannot be disposed of underground. To transport them all, quickly and safely, presents many problems.

The shafts must always be kept free from obstructions, fit and safe for the cages to go up and down. These are rectangular steel boxes travelling upright in the shaft. Top and bottom are enclosed and a middle floor divides the cage into two compartments, each high enough for an ordinary man to stand upright. Strong chains from the upper corners attach the cage to the winding rope by means of which it is lowered or raised. Anyone who has ever tried to lift a load at the end of a rope knows how that load will swing and spin unless something is done to prevent it. In the mine this is accomplished by attaching guide rails to the shaft framework and fixing clips or shoes on the sides of the cage to fit around these rails. In this way the cage runs on steel tracks almost like a railway train and at quite as great speeds.

The shaft is divided into two by a vertical framework so that two cages can be run, one in each section. One cage ascends as the other descends. Stations on this vertical railway are arranged at each level where coal is loaded. The shaft continues some distance below the lowest stopping place to form a sump where water draining from the mine workings can accumulate to be pumped to the surface.

A small group of men is responsible for the care of the shaft. Every week they examine it from top to bottom. To do this they travel on the roof of the cage, safety belts around their waists being attached to the supporting chains. The cage is lowered very slowly and with their powerful lamps they examine the shaft lining, the steel framework with its guide rails, the

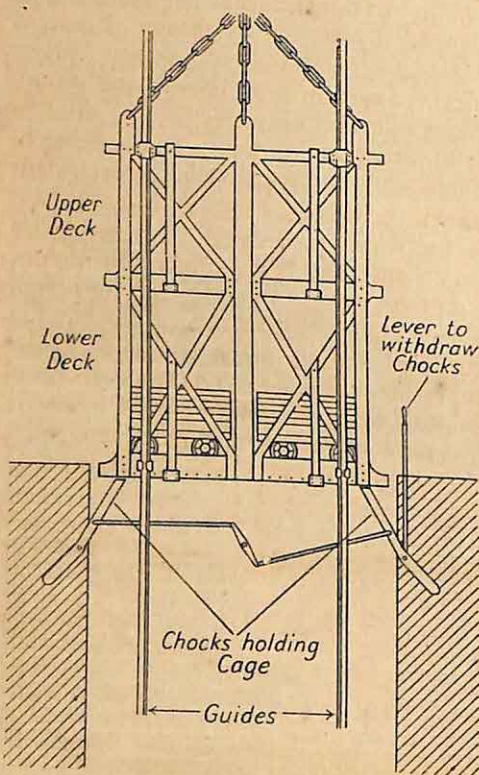
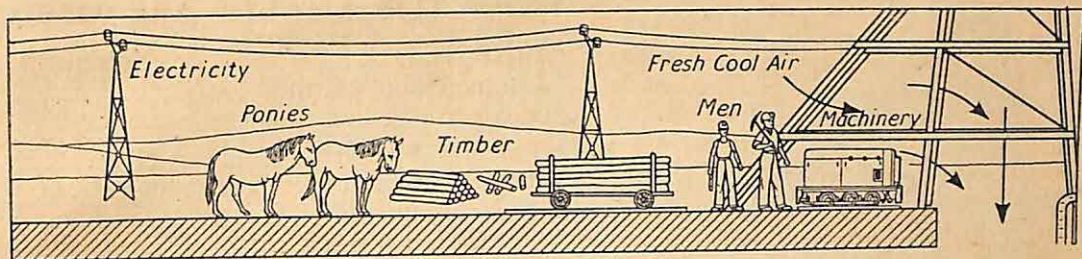


Fig. 52. A two-deck cage lifting four (or eight) tubs. The diagram shows the skeleton framework only of the cage.



pipes from the sump to the surface pumps and the cables carrying electricity to the workings. Any defects such as loose rock, worn or cracked rails, are noted and repaired at once. The life of everyone travelling in the shaft depends on their work.

The winding rope is immensely strong and consists of many strands of steel wire twisted together. It passes from the cage over the great pulley wheels high above the shaft and into the winding-engine house. There it can be seen coiling on and off a great steel drum as the cages run. The two ropes are wound on the drum in opposite directions so that as it turns one is coiled upon it and the other paid out. The winding engineman sits by the controlling gear in front of an indicator which shows the position of each cage in the shaft. Sometimes this shows two model "cages" moving in slots on a board on which is marked the position of each stopping place. Sometimes it is like a clock face with two hands turning in opposite directions. The stopping places

take the place of hour figures around the edge.

At the top and bottom of each shaft and at each stopping place there is a man in charge who signals when all is clear for the cage to move. Nowadays he can usually telephone to the surface if necessary but he still generally signals by means of bells—one ring for "lower away", two for "haul up", three for "men on board" and so on.

Many clever safety devices are used to prevent accidents or lessen damage due to mishaps. Thus there are gates at each shaft level which the cage raises as it passes and then drops into place again. Another device prevents the cage being drawn too high at the surface by disconnecting the rope from the cage chains, whilst others prevent the cage from falling down the shaft if the winding rope breaks. The rope itself is constantly inspected and replaced before it shows signs of serious wear, a new one being always kept in stock ready for immediate use.

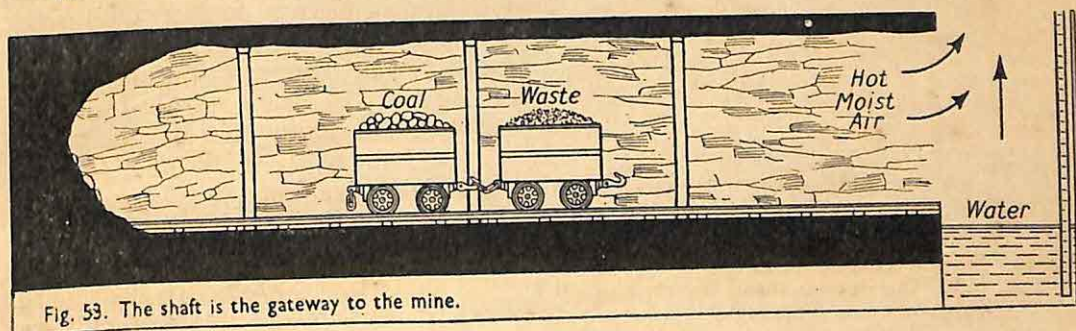


Fig. 53. The shaft is the gateway to the mine.

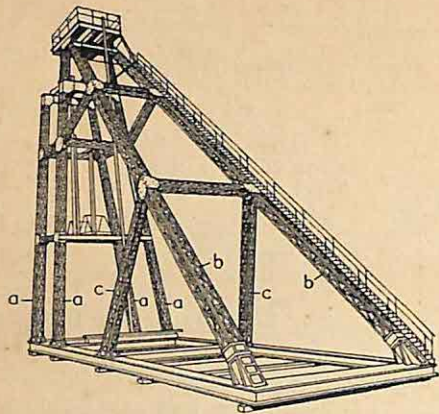


Fig. 54. The steel framework of a modern pithead gear. Can you see any advantage in building the main parts of lattice work instead of solid?

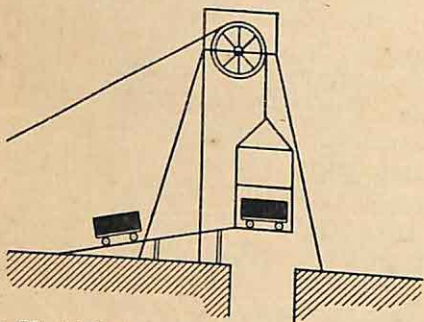
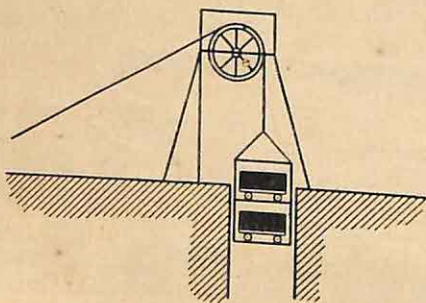


Fig. 55. (a) Pulley wheels high above ground level.



(b) Pulley wheels nearer ground level.

1 Figure 54 shows the steel framework of a pithead gear. Why are the supports for the pulley wheels (*a, a, a, a*) splayed and not vertical? Why are there oblique supports (*b, b*) on one side only? What important building will be on the same side of the shaft? What is the use of the lower supports (*c, c*)?

Make a simple copy of the diagram and mark by arrows the direction of the pressures or pulls on *a, b* and *c*.

2 Why are the pulley wheels put high above the ground as in Figure 55 (*a*) and not as in Figure 55 (*b*)?

3 Why is the winding engine kept away from the shaft as in Figure 56 (*a*) and not put directly below the pulley wheels as in Figure 56 (*b*)? Why are the pulley wheels so large? (They are often 20 feet or more across.)

4 One way of breaking a wire is to bend and straighten it repeatedly, making the bends always at the same place. Try this with a piece of wire, bending it round a big nail or a lead pencil. How many times can you bend and straighten it before it breaks? Now try with another piece but using a cricket stump or chair leg instead of the nail.

Every inch of the winding rope is bent and then straightened as it comes over the pulley wheel—does the big or the little wheel, the engine close to or away from the shaft cause more bending of the rope? (X, Y and Z in Figure 56 show this.)

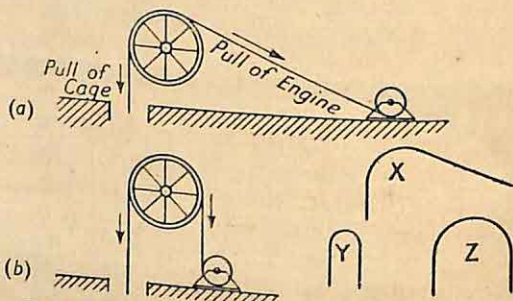


Fig. 56. (a) and (b) show two positions for the winding engine; X, Y and Z show the bending of ropes.

5 The cage is drawn up the shaft by winding the rope on a drum. To slow or stop the cage a brake is applied to the drum, a long band being pressed on its circumference. Which will raise the cage more rapidly: a small drum or a big one? Which can be braked more effectively?

6 In very modern mines the rope drum is conical instead of cylindrical. The rope winds on the small end of the drum when the cage is at the bottom of the shaft. Will the first part of its journey be slower or quicker than the later part? Which is the harder task, to start a thing moving or to keep it moving after it is started? Which is harder, to stop it when it is moving quickly or when it is moving slowly?

Can you explain the advantages of the conical drum over the cylindrical one? If you think of the three speed gear on your bicycle or of how the driver changes gear when he starts his motor car it will help.

7. Why does the cage come up the shaft and not the engine go up to the pulley wheels?

8 Amongst things used in the mine are: electricity, horses, long steel rails, compressed air for tools, timber, haulage engines.

Suggest means for getting each of these down the shaft to the place where it is needed.

9 Coal was first loaded into sea-going ships on Tyneside. Horse-drawn wagons brought it to the river banks where it was emptied into barges known as keels. These were rowed out to ships anchored in deeper water in mid-stream. ("The Keel Row" is a Tyneside song telling of this task.) To-day, where the banks are high, wooden jetties have been built out into the river, the ships come alongside, the floors of the trucks are dropped and the coal falls down shoots into the ships' holds. Where the shore is low, as in most coal ports, the trucks are lifted in great hoists and turned over so that the coal falls into the loading shoots.

Make sketches to show the three methods of loading.

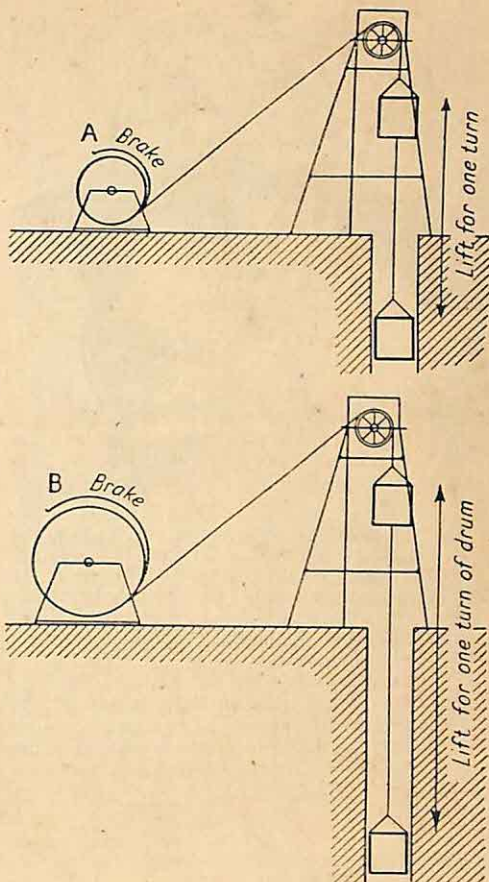


Fig. 57. Big Drum and Little Drum—which is better for (a) braking, (b) speed?

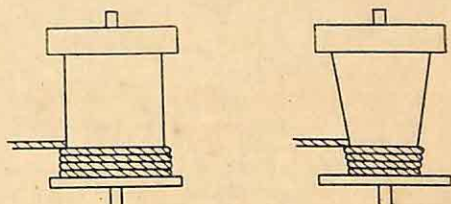


Fig. 58. The cylindrical drum winds the rope at a regular speed, the conical drum on the right winds at an increasing speed.



Fig. 59. The miner's helmet is made of tough fabric. Its edges stand out beyond the wearer's head, especially the peak in front; all its surfaces are smooth and rounded; only an inner lining touches the wearer's head. What is the object of these features of the design? The bracket at the front carries the miner's electric lamp. Why does the miner wear little clothing at work? He now frequently wears a single outer garment of tough cloth. In what way is this better than coat and trousers?

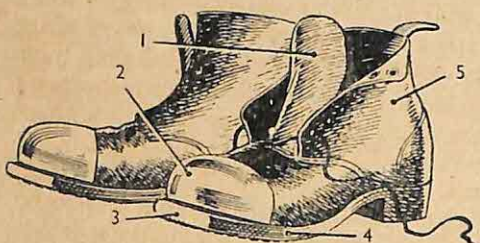


Fig. 60. A pair of miner's boots. The leather tongue (1) is wide, long and padded and covers the whole front opening; a strong steel cap (2) protects the toes and a steel band (3) checks wear at the front edge of the sole. The soles (4) and uppers (5) are of strong water-proofed leather. Why should so much care be taken over the miner's boots?

GOING DOWN THE MINE

THOUGH Bob Elliott had lived all his life amongst miners his father thought he should see what work underground was really like before he finally decided to start it. He therefore got permission for Bob and one of his friends to make a trip down the mine. At the time appointed, Mr. Elliott and the two boys waited at the colliery office for the under-manager whom they were to accompany. They went first to the bath house where the men changed into pit clothes and the boys left their caps and overcoats. In the lamp cabin, close by, each boy was fitted with a strong light helmet, an electric lamp which fitted on it, and a battery. The latter was carried on a leather belt fastened round the waist. They noticed that the lamps and batteries hung on numbered racks and that these numbers and their names were entered in a register. In this way a check is kept on everyone going down the mine. Thus equipped they climbed the long iron stairway to the platform from which they would enter the cage. Here they were shown the railway tracks on which the tubs were run from the cages to be emptied in the tipplers and returned to be sent down the shaft again. As the cage arrived they moved to the pit mouth. Before they entered it the banksman ran over their pockets to see they carried no matches or other forbidden things. In this way the boys learned the miner's first lesson, to remember always that the lives of many men depend on their fellows doing nothing foolish. As the banksman said: "One fool in a mine is one too many."

As the boys stepped on the iron floor of the cage they both felt rather nervous, but the cheerfulness of the banksman as he signalled to the engineman to "lower away", with the caution "men on board", reassured them. But only for a moment, for as the cage dropped quickly away they felt a very queer sensation which made them both gulp quickly as though they were trying not to cry. That soon passed and then they watched with interest as the

dripping framework in the shaft slipped past. The cage ran swiftly and smoothly for a time and then to their amazement it appeared to be going up instead of down! They looked up and saw their guides smiling—it was not some queer sort of accident then, but something that always happened. The under-manager explained that the engine-man had put on his brakes and the cage was slowing down. Just as one seems to be thrown forward when a train slows on approaching a station, so in the cage one's weight is thrown downwards and it feels as though the cage is coming up.

The cage journey seemed still more like a night journey in a train when the boys stepped out a few minutes later, for they found themselves in a brightly lit open space with the roof high above them. Narrow rail tracks led to the shaft from opposite directions, each disappearing from view along a tunnel whose whitewashed walls and electric lights were as bright as a London Underground station. These tunnels were the main roadways of the mine and led away for a couple of miles to the coal face where the miners worked. Quite ordinary mines have rail tracks longer than the tramway system of a good-sized town.

The first part of the journey to the face was made by "tram", a tub with seats, drawn along the rails by a strong wire rope. The boys now felt they were getting to the real coalmine as the tunnel grew narrower and less well-lit. At every few yards mysterious dark tunnels opened off the main way along which they were travelling. After a time their tram stopped at one of these side openings and they got down to walk. Now they were glad of the lamps on their helmets for these were their only lights. In their beams they could see the piled-up stone and the strong upright timbers that supported the roof on either side, where the coal had already been removed.

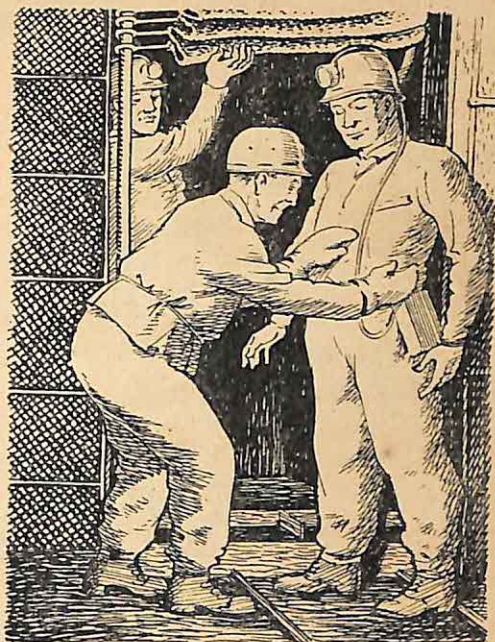


Fig. 61. The banksman makes sure the men are not carrying matches or tobacco into the mine, checks lamps to see they are working properly and closes the cage gates before signalling the engine-man: "Lower away, men on board."

Soon they came to the coal face—a long low wall of shining coal stretching far away in either direction. As they moved along here, crouching low to avoid bumping their heads on the roof, they had many questions to ask their guides about all the strange machinery they saw there, about the many tunnels leading away from the coal face, and about the different jobs that had to be done to break down the coal and get it out of the mine. All their questions were answered as they made their way back to the shaft and up once more into the daylight. You can ask these questions yourself and find out the answers from the next sixteen pages of this book.

THE PLAN OF THE MINE

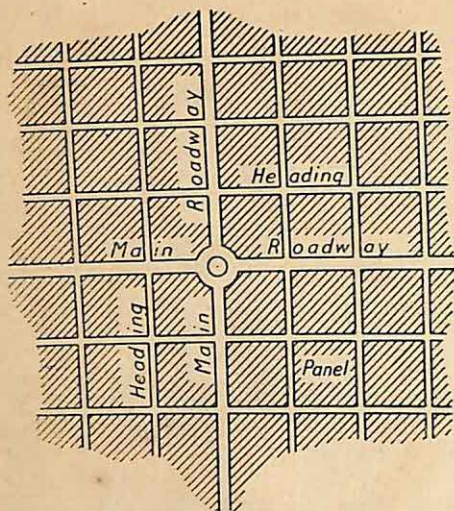


Fig. 62. General lay-out of mine workings on room-and-pillar system. The roadways and headings cut up the seam into panels each of which is mined in turn.

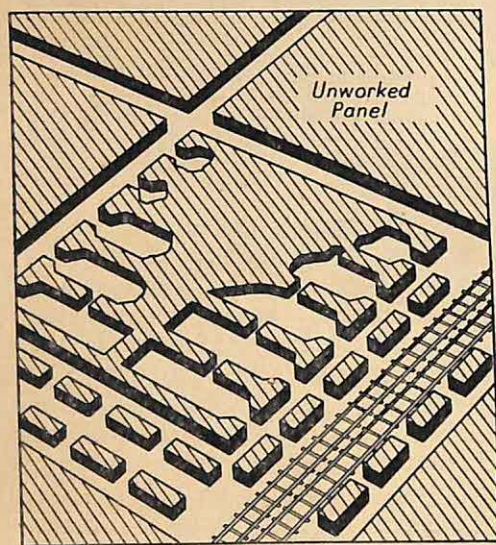


Fig. 63. The method of working a panel by rooms. Notice the pillars of unworked coal left along the roadways to support the roof. Rooms are cut out in turn in the coal and later on the walls between them are removed where possible.

ONE of the most surprising things to Bob and his friend was the great number of roadways they found underground. It looked a very easy place in which to get lost, for there were no street names or signposts, yet their guides seemed not a bit troubled by it. The boys were told that very accurate plans were kept in the mine office and another simpler one at the pit mouth though the men hardly needed it for they knew the pattern of the workings. There are really only two patterns, known as *longwall working* and *room-and-pillar working*.

As soon as the shaft has been sunk and equipped, four main roadways are cut, as far as possible in the coal seam itself, but they must be high enough and wide enough for the coal to be hauled quickly and easily to the shaft. Two of these roadways follow the main cleat and two the lesser cleat.

In room-and-pillar working, side roads, called *headings*, are opened up into the coal at intervals of a hundred yards. These cut up the whole area to be worked into great square blocks or panels. These are then broken up by the miners who cut into them at twenty-yard intervals and proceed to carve out rooms fifty yards back into the coal. Until this is completed pillars of coal are left between the rooms and along the roadways to support the roof. When the room has been worked out it is abandoned and the roof allowed to fall in, though some of the coal in the pillars may be got out first. In Britain this rather wasteful method is not so often followed as it used to be, except where the seam is so near the surface that some coal must be left to support buildings and streets. It is, however, far the commonest method in the thick seams of American coal mines.

Longwall working is the usual British way of coal getting. It is well named, for the face is exposed along a considerable length and the coal is removed all along this, so that the working face retreats as though it were a wall which was being pushed back. The main or *gate road*

leads to the middle of the face and is used chiefly for hauling the coal away. Two other roads, the *tail gates*, lead from the ends of the working face back towards the shaft. They afford passages for bringing in materials and for men to leave or enter the working areas without danger from the trains or trucks. They play an important part in the system of ventilation of the mine. A longwall face may be two hundred yards long and may be worked back anything up to six feet in a day.

Longwall working is economical, because practically all the coal is removed, but it calls for the use of more timber or steel to support the sides and roofs of the lengthy roadways. It is especially suitable for working thin seams. The stone which has to be cut from roof or floor to enable tubs to get near the face for loading is built up into thick walls along the roadways to help to support the roof. In the spaces left behind these walls the roof is allowed to fall.

Whichever method of working is adopted the coal is left undisturbed for some distance around the shaft so that falls of roof are not likely to affect the shaft walls or the steel frames in which the cages run.

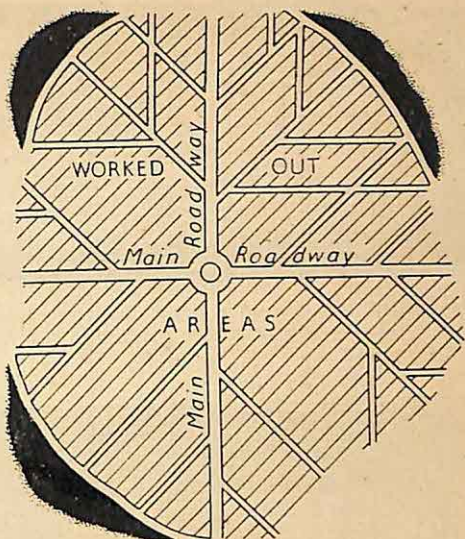
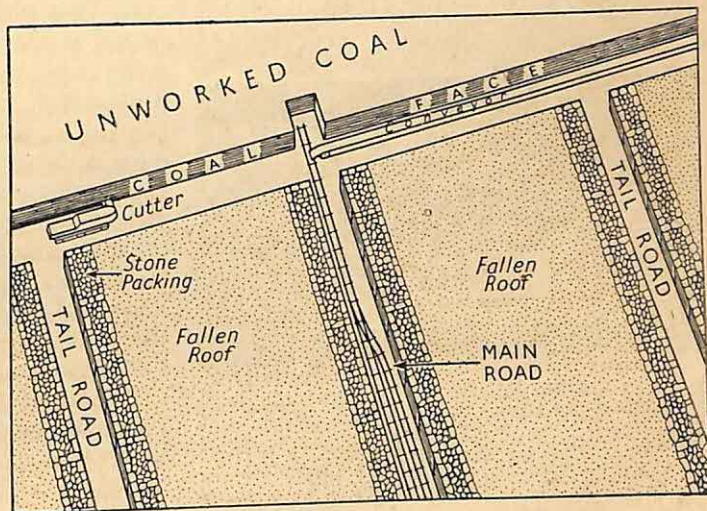


Fig. 64. General lay-out of mine workings on the longwall system. In this case the coal is being cut farther and farther from the shaft as mining proceeds. The system can be applied by beginning at the outer limit of the area to be mined and working back towards the shaft. In that case only the main roadways from the shaft to the mine boundary would be cut at first.

Fig. 65. The working face in the longwall system. As the coal face retreats, waste stone is packed along the roads to support the roof there. This packing must be made very solid and firm. Over the rest of the space the roof is allowed to fall.



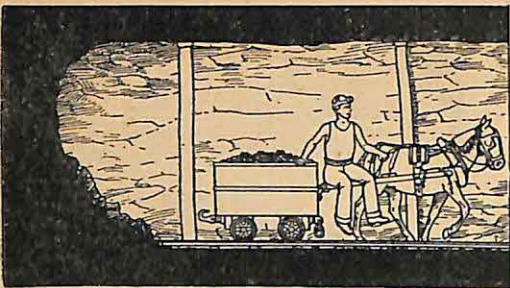


Fig. 66. How the old miners began—as drivers hauling single tubs from the face to a main roadway.

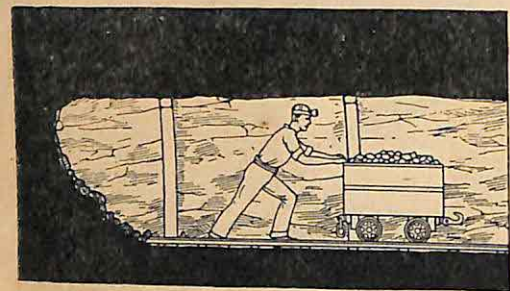


Fig. 67. The next stage—the putter. Strong young fellows, 18 to 20 years old, pushed out the loaded tubs by hand where the roof was too low for pony haulage, or made up into trains on the main roadway the tubs brought there by the drivers. What did the putter put?



Fig. 68. The stoneman. He breaks down the stone roof or takes up the floor to make ways large enough for haulage. He also sees to stone packing along the roadways and generally looks after all roads, keeping them clear and fit for haulage.

HOW I BECAME A MINER

THIS is the story told by Bob's father: "Thirty years ago, when I left school, lads hadn't much choice in this village—it was pitwork or nothing for most of us. Not that we bothered about that mind, for we didn't think much of the chap that chose any other job. I wanted to go down the pit, not to have just a surface job, so I started as a driver. The horsekeeper saw I had a quiet pony and showed me how to yoke him to a tub. He was called Diamond and we soon became good friends. Our job was to haul out coal from near the face to the main roadway and take empties back. It wasn't heavy work for either of us, unless the track was bad, and then we both suffered—Diamond because it made the tubs heavier to pull and I because when tubs ran off the track it was hard work getting them back. We had to do all we could to keep the tubs moving because the coal hewer's wage depended on the number he filled. After a year or two I was put on longer hauls with a bigger horse and then when I was eighteen I got a new job.

"I became a putter. Like pony driving that's a job that has vanished from all but the older pits, and a good thing too, for it was hard work and many a young fellow crippled himself at it. Tubs had to be pushed out from where they had been filled to where the roof was high enough for the ponies to work. Some of us worked on the main roadways getting the tubs from the drivers on to the main track and making them up into long trains of up to a score or so, to be hauled away to the shaft. You had to be quick about that job, but you could at least stand up and straighten your back and you couldn't do that at the face.

"In my early twenties I had a spell with the stonemen. That meant night work every shift so I moved on to hewing as soon as I could. The stonemen went to work when most other miners were at home, for

our main task was to look after the roadways. Sometimes we cut new roads to open up fresh working districts but generally we had enough to do repairing the old ones. To get the tubs up to the coal face we had to cut away the roof or take up the floor. That generally meant drilling holes and charging them with blasting powder to fetch down the roof rock. We soon learned how and where to put the holes, and how big a charge to use to bring down what we needed without smashing up the roof and causing a big fall. Of course we had timbers to fit, to support the roof, and stones to pack, to make the sides of the roadways safe and solid. It was often risky work, especially in some seams where the roof rock was loose and broken. If this fell it might block the roadway for yards and I've seen it smash nine-inch posts as if they were matchsticks. We'd often work for days clearing away the fallen stuff and building up the walls and roof with new timber.

"When I was twenty-six I changed over to hewing. It was then I got married. Hewers, you see, are paid by the amount of coal they get out, and being young and strong I was sure I would make plenty of money at it. Sometimes I didn't do so badly, but there were times when my pay packet hardly paid the grocer's bill, even after I had done a hard week's work. How we tackled the job depended on the place and especially on how the cleat was running. If it ran across our working face we could get the point of the pick in at the side and split the coal off in sheets, but if we were working end on it was slower and harder work. In some seams where it was safe to use explosives we cut a deep groove along the bottom of the coal, next the floor, and then drilled a couple of shot holes at the top and blasted it down.

"Now I am a deputy, or fireman as they call us in some coalfields. That's a very responsible job and only experienced men

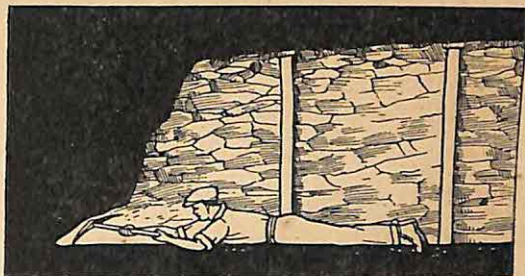


Fig. 69. The hewer—the skilled craftsman of the old days. He broke down the coal at the face and filled it into the tubs. He knew all about cleats and the way in which the roof settled and so made easier or more difficult his task. Brains as well as brawn were needed in his work.



Fig. 70. The deputy or fireman—now the experienced miner takes over supervision of his fellows. He tests for gas, examines the roof and the timbering before the hewer begins work, and sees to the safety of all workers in his district.

who have passed an examination can hold it. It's rather like being a foreman in a factory because I have to take charge of a district and keep an eye on all the men and lads working in it. But mainly I have to see things are safe for the men. Before they can begin work I check the roof in the working places to try and make sure there will be no falls and then, when they are at work, see they fix plenty of timber to keep it safe. Then I have to test for gas before any blasting is done and keep an eye on ventilation. If I do my job properly the fellows in my district can get on with their work without worrying—they know that what can be done to take the danger and discomfort out of mining has been done."

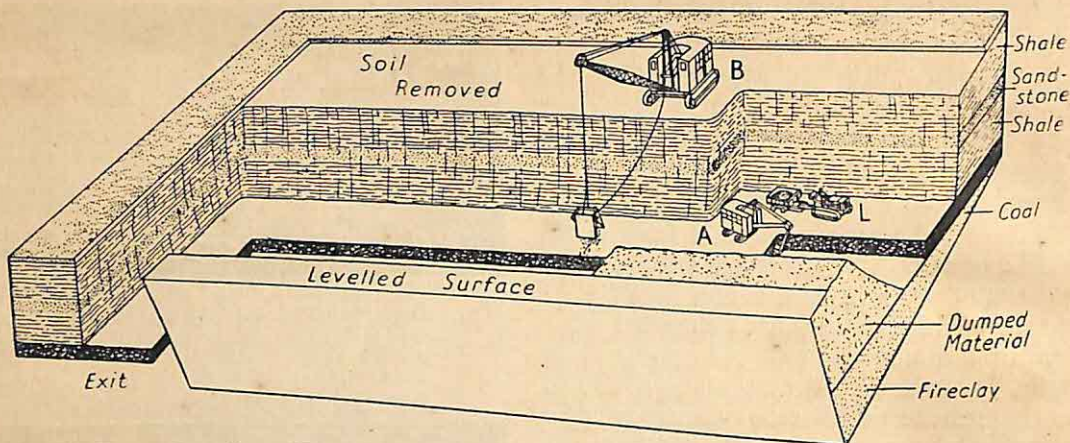


Fig. 71. Opencast working. The soil has already been taken off and piled ready for replacement. Now the dragline tears up the rock overlying the seam and dumps it across the open working. The power shovel digs up the coal and loads it direct on the lorry. The dumped material is packed and levelled and the soil is then spread over it again so that the land can be used once more for farming.

WINNING THE COAL

IN the early days of mining, coal was just quarried from the hillsides where it outcropped. Tunnels or drifts were later cut into the seam to reach the more deeply buried areas and roadways made to open it up. In other areas the coal was so near the surface that it could be reached by open pits sunk through the soil and rock overlying it. The coal was then hoisted in kibbles, raised by a horse gin or a simple windlass, such as is used to draw water from a well. Modern machinery has made the mining of such shallow seams much easier and far more efficient, and nearly a quarter of a million tons a week is now obtained from these open-cast workings. The diagram shows how this is done. The soil is removed first and stacked near by so that it can be replaced later. As work proceeds the *dragline* (B) excavates the rock above the coal seam and dumps it in the workings from which the coal has been previously taken. The *power shovel* (A) tears up the coal and loads it into the lorry (L) which carries it away to its destination. The dumped material is then levelled and

packed firm and the soil replaced. The land can then be returned to agricultural use at once. No ugly refuse dumps are left and no permanent buildings or railway tracks are needed. Seams up to sixty feet deep are now worked in this way. The method is cheap but the coal is seldom of good quality.

Far the largest part of our coal is obtained from shafts, up to 3,000 feet deep in some cases. Such a shaft might cut half a dozen workable seams, varying in thickness from two to twenty or more feet in exceptional cases. When each has been opened up by roadways the getting or winning of the coal begins. In the old days this was the work of the hewer, who broke out the coal from the exposed face with his pick and shovelled it into tubs. Where it was safe to do so explosives were used to help in breaking down the face. Bob's father has already told how he did this by undercutting the face and then blasting down the overhanging coal. Each hewer had his own stall, or face, and worked in it alone during his shift.

To-day this is being rapidly changed. The coal in modern mines is cut by machinery.

In some cases the coal is ripped off the face by a pneumatic pick. This is similar to the noisy tool now so often used in breaking up road surfaces when cables or pipes are to be laid. Its chisel end is driven into the coal along the cleat or grain by compressed air and, when deeply buried, a wrench on the tool brings down a mass of coal. This is a noisy and dusty job, but it is much speedier and less tiring than the old fashioned hand hewing. In the coal cutter, a series of short picks is attached to a strong chain which passes round a pair of sprocket wheels in much the same way as a bicycle chain. The cyclist and his pedals are replaced by a small electric or compressed air engine over the driving sprocket. The other wheel is at the end of an arm which reaches out towards the coal face. As the engine drives the chain round the picks cut into the coal like the teeth of a saw cutting into timber. In longwall working the whole machine drags itself forward and so undercuts the coal several feet back from the face. With one man at the engine, another to clear the small broken coal from the cutting chain and a third to follow up and drive in wooden wedges to support the coal and keep the cut open, such a machine can cut a face 200 yards long and 6 feet deep in one shift. Behind it come the drillers who, with a boring machine, make the series of holes near the roof for the blasting charges which will be fired at the end of the shift to bring down the undercut mass. These men form a team who replace the old single hewers, each at his six-foot face. A later type of cutter makes three cuts at once—one at floor level, one half way up the face and a third vertical cut behind the other two. In this way no blasting is required, the cut off coal simply falling clear of the face ready for loading.

By this mechanized system of mining fewer men, doing less heavy work, win the coal from the seam far more rapidly than was possible by the old methods. About three-quarters of British coal is now machine cut and every year the proportion is increasing.

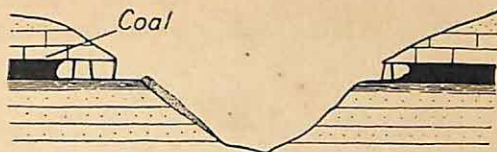


Fig. 72. Drift or adit mining in a coal seam where it opens on a valley side. This is one of the earliest methods of coal mining. What difficulties will be met with in working the seam far back into the hillside?

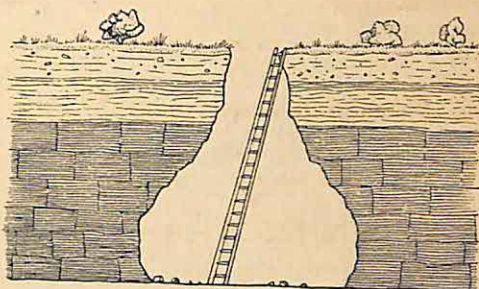


Fig. 73. A Staffordshire "Bell" pit. An early way of mining a shallow seam. The pit is widened in the coal at the bottom until the overlying rock begins to fall. Then a new pit must be opened. Why did this method leave behind far more coal than modern opencast mining?

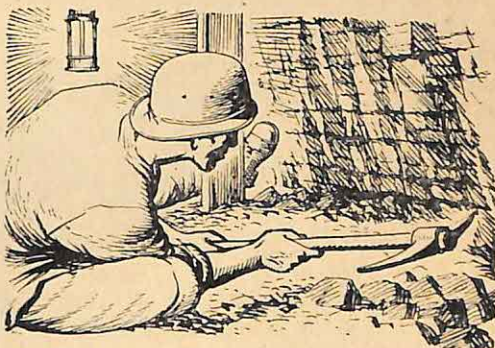


Fig. 74. A hewer "kirving" into a seam. He cuts a groove deep along the bottom of the coal face so that the upper portion may be blasted or broken down. The method is used when cutting into the seam in the direction of the main cleat.

LOADING THE COAL

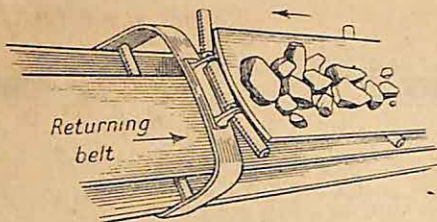


Fig. 75. A flexible type of conveyor belt. The belt of canvas and rubber passes over rollers, carrying the coal from the face to the tubs. In the diagram the belt is cut off at the rollers to show it returning underneath.

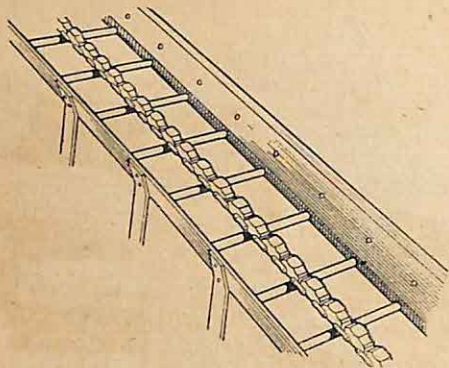


Fig. 76. A chain conveyor. The "belt" consists of steel sheets linked together by a sprocket chain like that on a bicycle.

IN the older method of coal-getting the hewer broke loose the coal and loaded it into tubs which the putter pushed out to the driver and his pony. These took them to the main roadway where they were made up into sets or trains and drawn to the shaft. There they were loaded into the cages—four, eight or even sixteen at a time—and hauled to the surface for emptying. They were then returned to the coal face by the same means. All this is altered in the most modern mines and even in the older pits many changes are being made.

The broken down coal is now usually carried to the main haulage road by a conveyor belt. This is simply a shallow trough of fabric or steel sheets, forming an endless belt passing round rollers at either end. It is put into position along the face and loaders shovel the loose coal on to its moving surface. This carries it forward to an upraised end beneath which an empty tub is placed. The coal is thus carried along the face in a steady stream which empties into the tub as the sections of the conveyor pass over the end roller to travel back beneath the loaded portion of the belt.

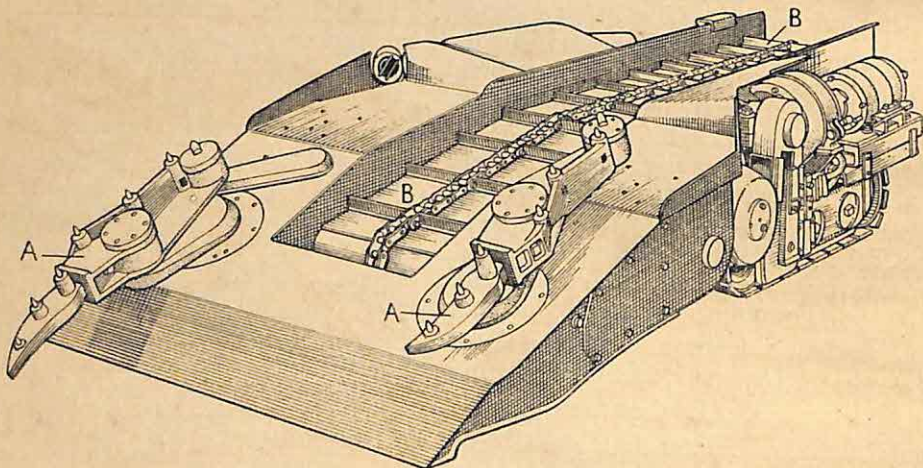


Fig. 77. The Joy loader. The swivel arms AA sweep the coal back to the central chain conveyor BB.

Shovelling coal to the conveyor is a tiring and back-breaking job, especially where the seams are not very thick, and ingenious machines are now being designed to make it unnecessary. One type has a flat, shovel-like head which burrows beneath the loose coal and shakes it up and back to the conveyor. It is called a duck-bill loader because its movements are like those of the bill of a duck as it feeds in the soft mud at the bottom of a pool. Another type has two strong arms mounted on the shovel end. These dig into the coal and gather it back to the conveyor just as a boy would gather a double armful of hay or straw from a heap.

The ideal arrangement would be of course one in which the coal falls on the conveyor as it is cut. The most modern machines used in longwall working are getting very near this as they leave little work for the loader. This is just one more way in which the heavy work of mining is being reduced. Miners, loaders and conveyor men now work in teams, each with his own job, but all fitting together like the players in a good football team. In this way the same number of men are able to produce more coal per shift worked than was formerly possible.

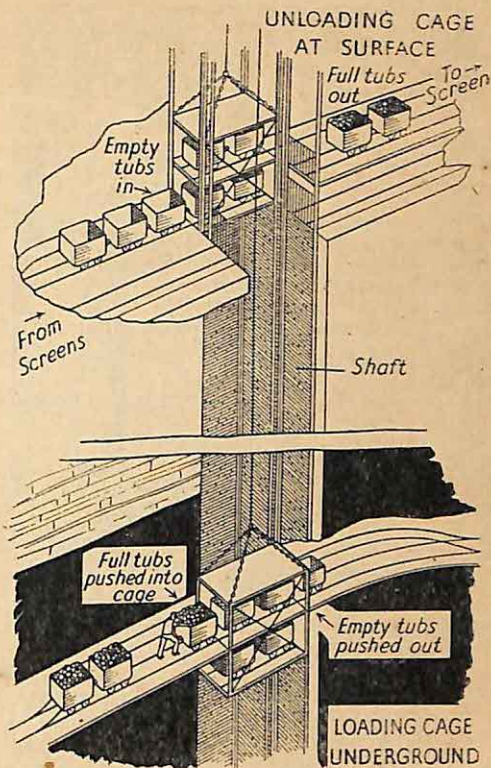
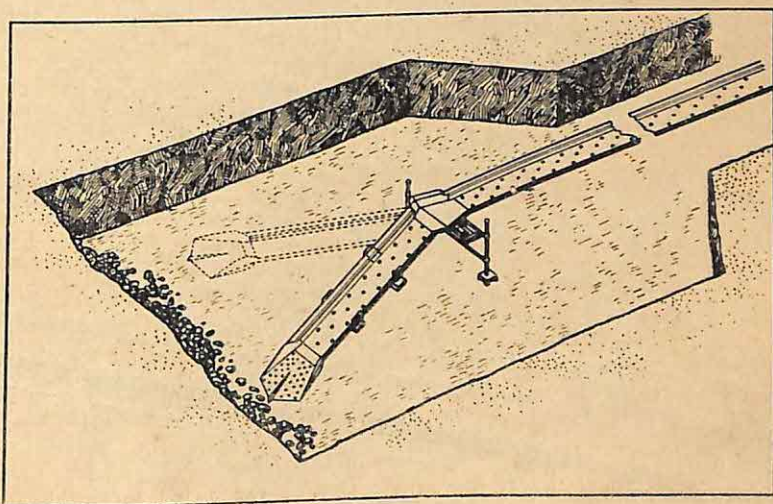


Fig. 78. The handling of tubs, with double deck cages, at the top and bottom of the shaft.

Fig. 79. Duckbill loader at work in a "room". It is specially suited to work in these conditions where there is space to swing the "bill" but only a narrow entrance between pillars for its short conveyor.



HAULING THE COAL

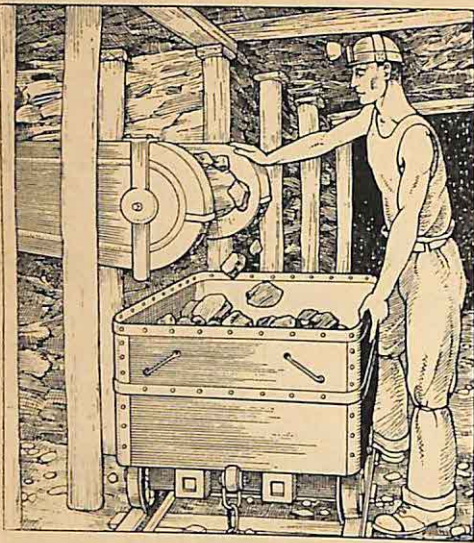
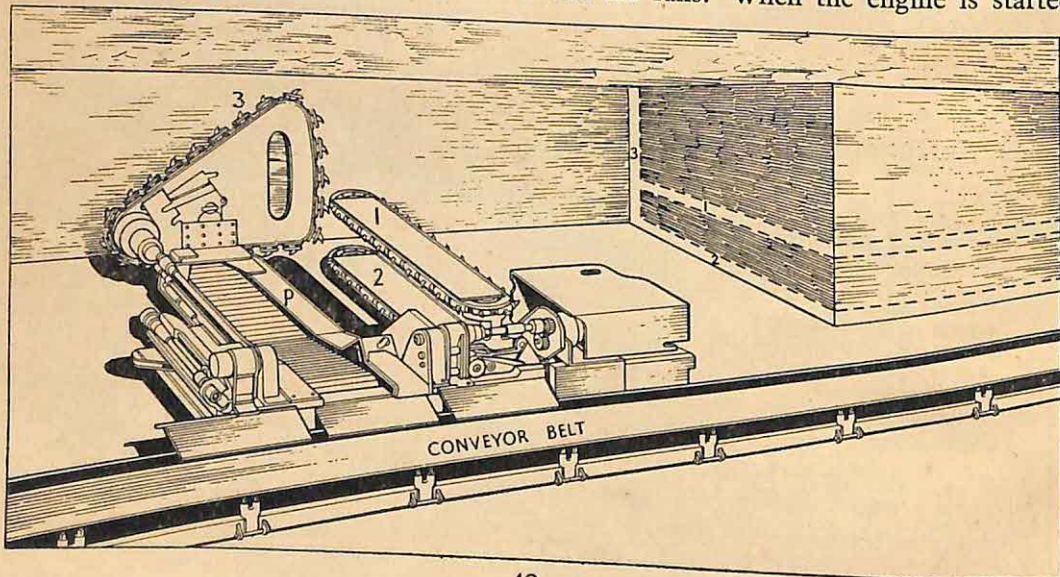


Fig. 80. The outer end of a conveyor belt where the coal falls from it into the waiting tub.

Fig. 81. A modern cutter. As it advances it makes two horizontal cuts (1, 2) and also one vertical cut (3). The falling coal drops on the moving platform P which carries it to the conveyor belt.



IN some mines the broken down coal from the rooms is carried to the conveyor belt or the tubs by means of shuttle cars. These are long low steel trucks holding three or four tons of coal. They have their own engines and are mounted on thick rubber tyres. The driver sits on a low seat along the side of the car and controls it just like a lorry driver. The chief difference is that instead of turning the car the driver turns round in his seat to drive it back for reloading since it is too long to turn in the mine roadway.

In any case the coal makes the last stage of its journey to the shaft in tubs or cars along a narrow-gauge railway. For many years, tubs have been drawn away and empties returned by main and tail haulage. An engine at the shaft bottom drives a pair of drums on which the hauling rope is coiled. A steel-wire rope runs from one drum to the end of the roadway around a fixed pulley there and on to the rear end of the train of tubs. Another runs from the front of the train to the second drum. Both ropes run over rollers laid on the ground between the rails. When the engine is started

it draws the main rope attached to the loaded tubs and thus brings them to the shaft. At the same time the tail rope from the other drum is dragged along behind. To draw empties from the shaft towards the face the tail rope is attached in front, the main rope behind and the engine reversed. At the loading point the ropes are shifted over again to a full train and the process reversed. This method can be used on quite steep roadways and is therefore specially valuable in mines laid out in the old way with the roads following the dip of the coal seams.

In modern mines much bigger cars are used and these are generally drawn by locomotive engines, the roadways having been made level to suit this quicker style of haulage. The engines are either electric or diesel (oil) driven. In the newest pits the tubs are not brought to the surface but are tipped underground into special box cages called skips. This is necessary whenever big cars are used since these cannot be run into the cages because of their length. To get such engines and their cars into the mine they must be slung below the cage.

Fig. 84. A shuttle car in action.

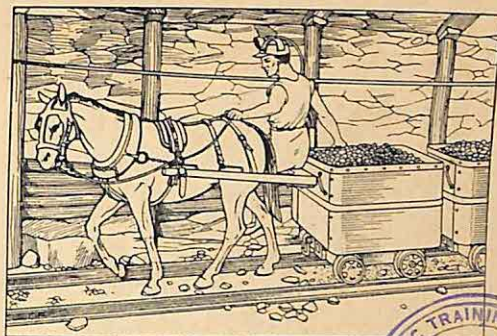
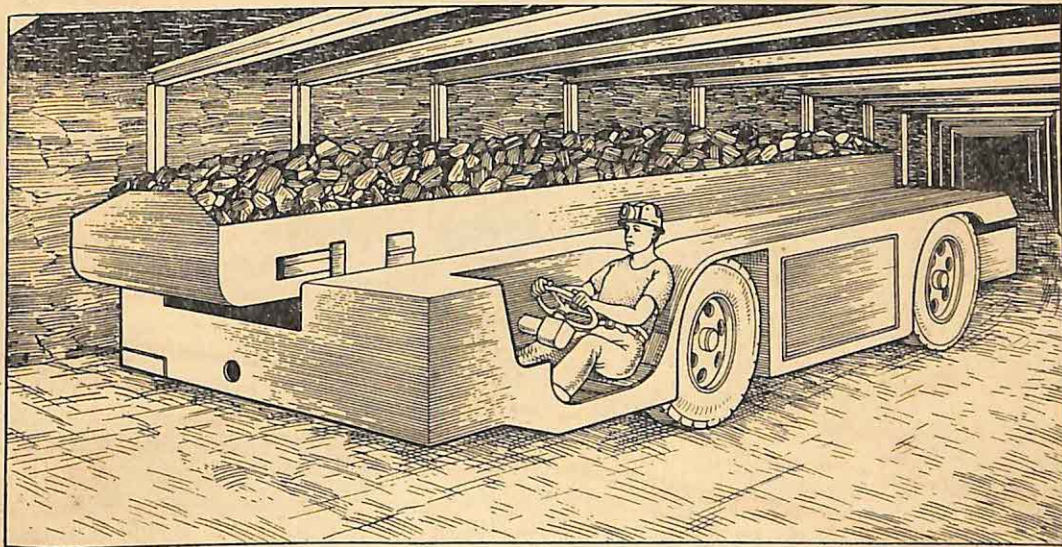


Fig. 82. Old style haulage with a pit pony.

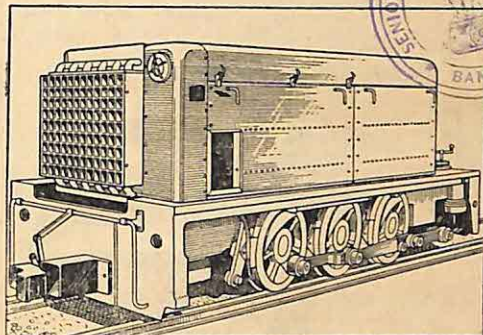


Fig. 83. New style haulage — a diesel locomotive.

SAFETY IN THE MINE

COAL mining is dangerous work but there are few employments where greater care is taken to prevent accidents occurring. Government regulations for the control of mining have been issued for many years and inspectors see that these are carried out.

Wherever coal is removed or a roadway cut there is danger from falls of the roof. To give protection against this both walls and roof are lined with timber or steel supports along all roadways and the main ways are often lined with brick or concrete. Regular inspections make sure that broken supports are replaced and weak places strengthened. In the coal workings such continued care is neither necessary nor possible. Once the coal has been removed the roof is allowed to fall. Near the face however, where work is going on, falls must be prevented. Two methods are used—timbering and packing.

Timbering is usually quickly done and gives good support for a time. Upright posts are fixed between roof and floor and wedged firmly against horizontal beams close to the roof. A cheaper method, because smaller and more easily handled pieces of timber can be used and more of it withdrawn to be used again, is to build up piers or columns of crossed beams. The kind of rock forming the roof will determine the method used and the closeness of the supports. Packing is done with stone ripped from the floor or roof when it is necessary to give more room for tubs or machines.

Rock falls are the most frequent cause of accidents to miners but are not responsible for most fatal accidents. Darkness is the worst enemy because it makes difficult the avoidance of danger. Just as street accidents are more numerous on winter evenings so in the dark mine most fatal accidents occur on dark haulage ways. It was easy to trip over haulage ropes or be caught by tubs when the only light was the lamp carried by the rider on the first tub. Now locomotives carrying powerful headlamps

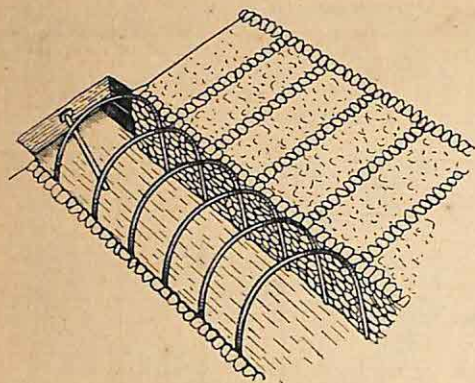


Fig. 85. Stone packing alongside roadway and steel arches supporting roof of roadway.

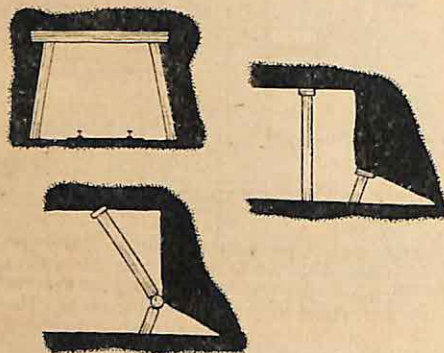


Fig. 86. Three types of timber supports.



Fig. 87. Roof supported by short timber packing alongside "shaker" type of conveyor.

avoid that trouble and the better lamps now carried by the collier help in the same way.

Water can be a source of danger in the mine. Some beds of rock hold a great deal of it and workings may set it free to flood the mine. Old and abandoned mines nearly always fill with water and great care has to be taken when working coal near them. All mines are fitted with powerful pumps to draw off the water which drains into the shaft sump.

The most terrible of all mine disasters are those caused by explosions. Some coals give off an inflammable gas when they are broken. If a mixture of this gas with air becomes ignited it explodes violently. An explosion may do immense damage throughout a mine, killing many workmen, shattering lamps and bringing down great falls of roof. It leaves behind a poisonous gas, known to the miner as "after-damp", which may cause the death of men seeking to escape from the explosion itself and is always a danger to those seeking to rescue the victims. Nearly every mine has its trained rescue workers ready to put on special masks and breathing apparatus and go to the help of injured or imprisoned men. It is often most dangerous work but no one hesitates if a fellow-miner's life may be saved. Fine, dry coal dust in the air is just as ready to explode as gas, so in many seams the floors and walls of the roadways are regularly dusted with finely powdered stone. This being heavier than coal dust prevents the latter being blown into the air by draughts along the passages. All mine lights and machinery are of special types so that they may not ignite gas or dust.

Some English mines are so dangerous that even to-day no electrical machinery or lighting is permitted in them and care is taken even in using such tools as pneumatic picks lest a spark from the rock should bring disaster. A jet of water playing into the hole and over the point of the pick does this whilst also converting the dangerous dust into mud.

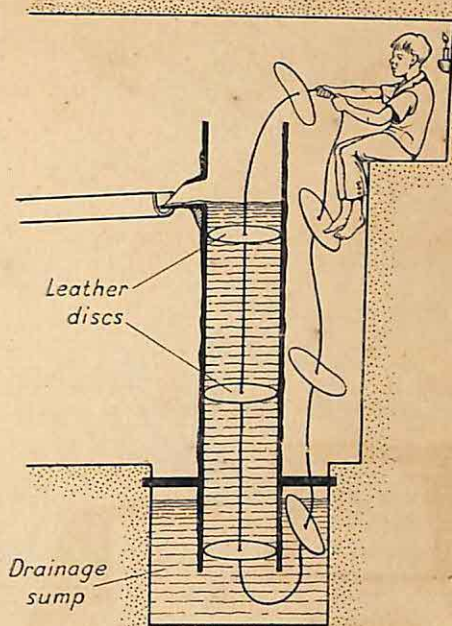


Fig. 88. An early type of pump found in a Durham mine. The water was lifted through a hollow tree trunk by pulling up leather discs attached to an endless hide rope. The water could not be lifted more than a yard or so by this means. Even then it would be very hard work for a boy.

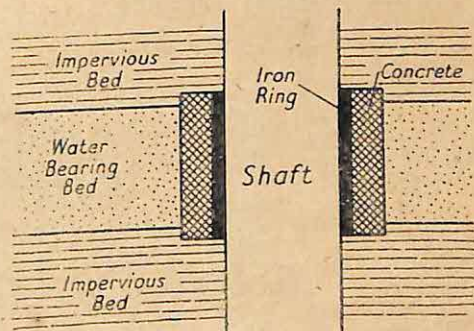


Fig. 89. Keeping water out of the workings. A thick ring of concrete supported by an inner iron ring holds back the water in the porous bed in this part of the shaft.

THE MINER'S LAMP

THE light of day is soon left behind when one descends a pit shaft and in all the workings it is darker than the blackest night at the surface. That is why in most pictures of the miner he is shown carrying a lamp—he could not see to work without it. In the very early days of mining torches were used, but by about two hundred years ago these had been replaced by candles and oil lamps. Boys driving ponies carried “midgeys” hooked in their coats or caps, whilst the hewers used “smokeys” set on the floor in their working place or hung from the timber supports. A “midgey” was simply a tin hood shielding the flame of a tallow candle pushed through a hole in its base and held in place by a lump of wet clay. The “smokey” was rather like a teapot containing oil, with a thick cotton wick sticking out from the spout far enough to be lighted.

As time went on, better lighting of this kind might have been provided but for the difficulty due to gas in the mine. This gas, being lighter than air, gathers near the roof and if present in the mine air in sufficient quantities any naked light will cause it to explode. In the olden days, if not much gas was given off, it was deliberately exploded by a “penitent” every day before work began.

Most of the great mine disasters have been caused by gas explosions and their possibility is still the most terrible risk the miner has to face. One February afternoon nearly forty years ago whilst eighty boys and girls sat in a Durham classroom an explosion occurred in the colliery just across the road. Sixty of those children lost a father, brother or uncle, and scarcely a dozen men were brought alive out of the mine.

One hundred and thirty years ago many such explosions were occurring in the then quite small Tyneside mines and a famous scientist, Humphry Davy, was asked to suggest some means of avoiding them. He set about producing a safe means of lighting—a lamp that

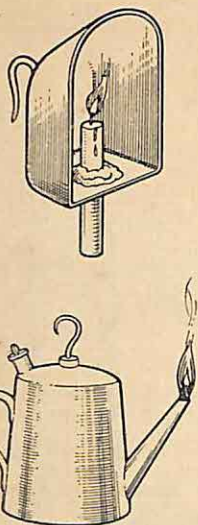


Fig. 90 The “midgey” and the “smokey”—two early types of lamp.

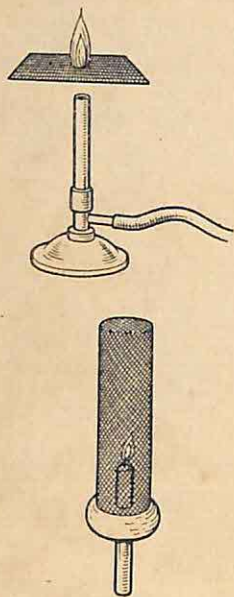


Fig. 91. The beginnings of the safety lamp—the flame cannot pass the gauze.

would give light without igniting the gas. This he did in 1815 by encircling the flame with a fine wire gauze. George Stephenson, the designer of the railway engine, solved the problem in much the same way at about the same time. The oil-burning safety lamp is still used in mines where gas is present, but nowadays its main value is as a gas detector—when gas is present it can be seen burning with a pale bluish flame around the yellow flame of the burning oil.

Even the best safety lamps give but a feeble light and many accidents occurred, and still occur, where lighting is poor. Electric lamps give far better illumination than any other kind and are very convenient to use so they are now generally employed. The roadways are lit by roof lamps to which the current is carried by covered cables and the miner's lamp is now rather like a cycle headlamp, attached to his helmet and fed by a battery carried in a leather case strapped around his waist. As the motor engine shows, an electric spark is quite enough to start an explosion and great care has to be taken therefore to see that cables, and lamps, and all switches and connections are made in such a way that sparking in the open mine air cannot take place.

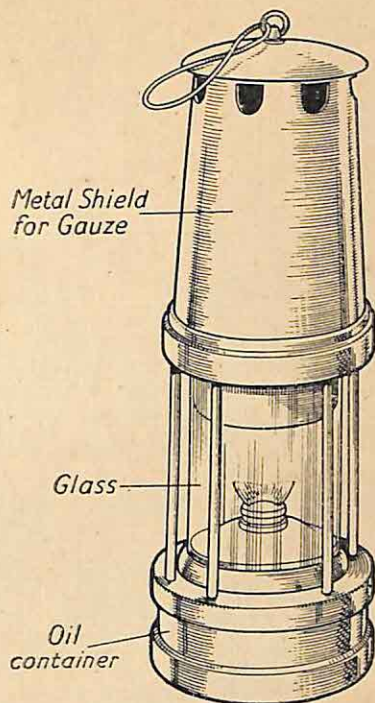


Fig. 92. A modern safety lamp for "gassy" mines.

Fig. 93. The modern helmet-carried electric lamp. The lamp lights up what the wearer looks at.



FRESH AIR IN THE MINE

MINERS at the coal face are often a couple of miles or more from the shaft. Their working places are warm and often damp. If they are to do hard work in such places plenty of cool dry air must be got to them by some means.

In the early days of mining, when pits were shallow and the tunnels only a few yards long, big bellows were used to blow air through wooden tubes to the working places. Modern methods all depend on the use of two shafts for each mine. One, the downcast shaft, carries fresh air into the mine; the other, the upcast, carries the used, foul air out. A simple model as drawn will show how this principle works. The air heated by the small lamp rises up one of the chimneys and fresh cool air passes down the other to replace it. The movement of the air can be seen if a lighted cigarette is held near the chimney tops.

The two shafts in the mine play the parts of the two chimneys in the box. Air from the downcast shaft is directed through the mine and finds its way out by the upcast shaft. In many old mines the up-draught in the second shaft was produced by burning coal fires at its base. This, of course, was dangerous if there was much gas in the mine and it is never used nowadays. Instead, a great revolving fan, fifteen

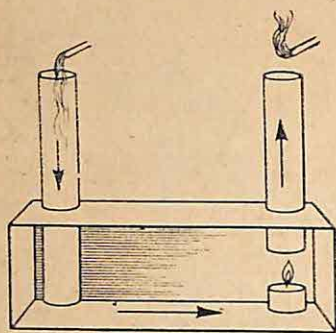


Fig. 94. Ventilation by two shafts. Note that cold air enters at the bottom of the box or tunnel, warm air is taken out at the top.

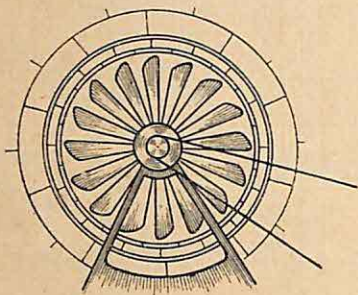


Fig. 95. Ventilating fan rotating in its tunnel.

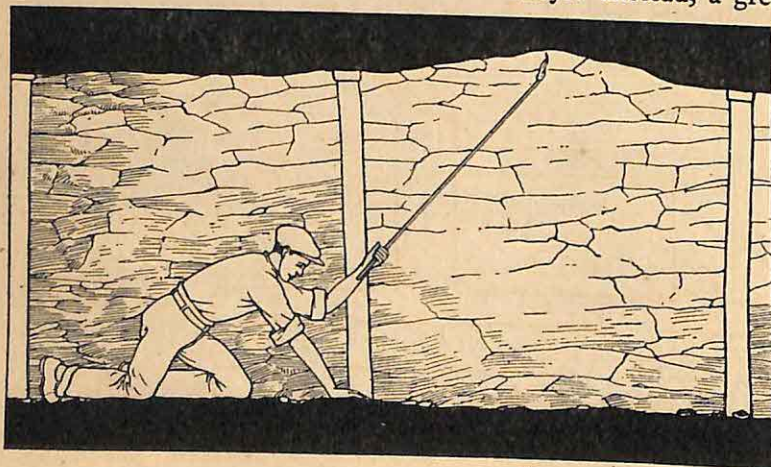


Fig. 96. An old way to deal with gas. Here the "penitent" crawls forward on his knees and explodes small pockets of gas collected near the roof. It was a very dangerous task.

or twenty feet in diameter, works in a closed tunnel leading from the upcast shaft to the open air and draws the foul air from the mine.

How is the air got to and from the coal face? The diagram below shows this. The main roadways are made double. Where it may be necessary to pass from one of these to the other, tight-fitting double doors are fixed so that when one is opened the other is shut. This prevents the air current along one of them from passing into the other. Air from the downcast shaft passes into the workings along one way and out to the upcast by the return airway. The diagram also shows how the air is directed from the main airway to the working faces (F) where the men are. Screens of heavy canvas called brattices (B) are put up to ensure this and are shifted as the work proceeds. In longwall working this sort of thing is less necessary as air can be directed to the face through one of the gates, pass along the face and return to the upcast shaft through another gate.

If conditions are good in the pit the draught of air can be felt in all the workings. Any failure in the air supply is quickly noticed by the experienced miner and the mine officials are constantly watchful. A good flow of fresh air not only makes working conditions more comfortable, it makes for greater safety too. The stream of air helps to carry away any gas that might accumulate and lead to an explosion.

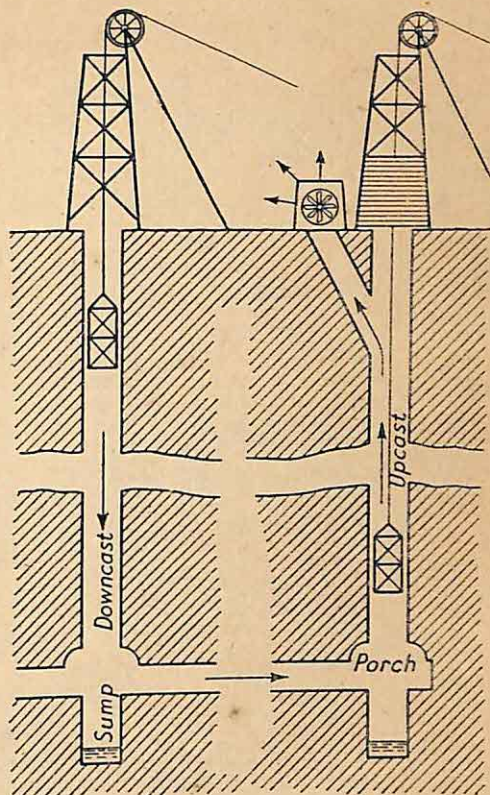
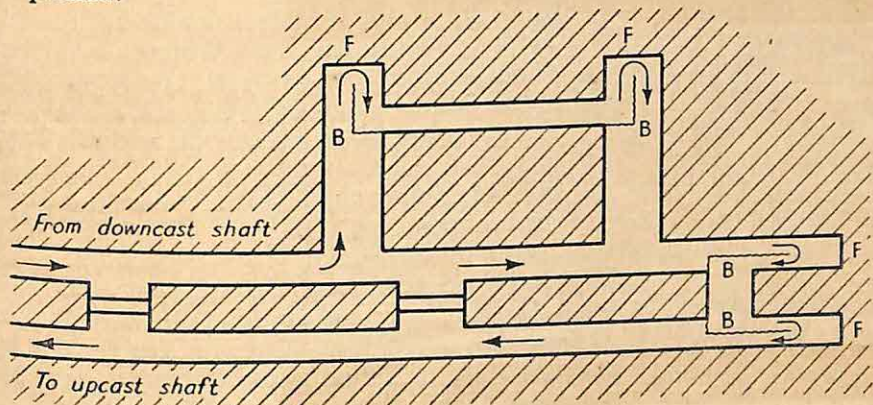


Fig. 97. The ventilation system of a modern mine.

Fig. 98. Directing air currents underground to the coal faces (F), where men are at work.



CLEANING COAL

IT sounds strange at first to speak of cleaning anything so black and dusty as coal, but it is done nevertheless at nearly every pit. Stone and dirt falling from the roof or picked up from the floor get mixed with the broken coal. In some seams thin layers of shale run through the coal and this too gets on the conveyor and into the tub. This useless stuff must be got rid of before the coal is sold.

The coal merchant supplies different grades or sizes to his customers according to the use to which it is to be put. Thus "large" coal is mainly used on locomotives and in open domestic fires, "cobbles" and "nuts" are suited for closed domestic cooking ranges and for boilers, coke ovens want "smalls" and some industries prefer "beans" or "peas". To sort out these grades from one another the coal has to be screened.

As the tubs of coal are drawn from the cage they pass over a machine where the weight of coal is determined and booked to the miner or team that cut and loaded it. One man does the weighing and another, chosen by the workmen, checks him to see that the miners get their due. The tub then passes to a tippler where it is turned upside down and emptied on the screen below. This screen consists of iron bars about four inches apart and fixed in a sloping frame so that the coal too large to pass between the bars runs from its upper surface to a steel conveyor belt. All the smaller stuff falls through to another belt which carries it to the washer. The large coal passes on its belt through a long room where boys pick out any lumps of stone. It then goes on to storage bins for loading and dispatch without needing further treatment.

In the older mines the smaller stuff was simply passed through a series of screens with closer bars or smaller holes to sort it into cobbles, nuts and so on. In modern practice it is cleaned before screening. There are several ways of doing this but all depend on the fact

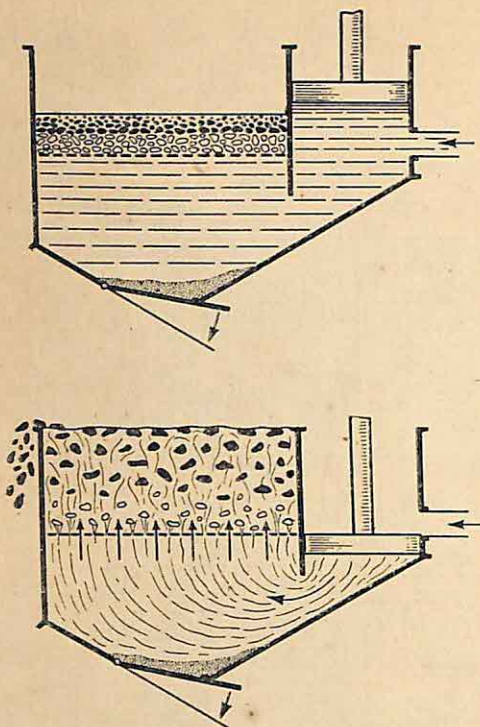


Fig. 99. One type of coal washer. The water forced up from below washes the lighter coal over the edges. The heavier stone and dirt fall back on the grid.

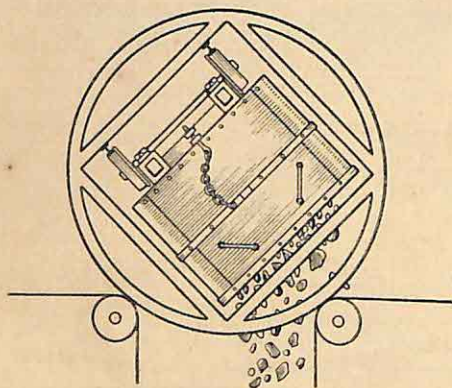


Fig. 100. The tippler turns easily sideways and upside down to empty the tub.

that coal is lighter or less dense than other rocks found with it. Thus in dry cleaning the rough coal is passed slowly over a shaking grid through which a strong current of air is blown. This brings the lighter coal to the top and allows the stone to fall to the bottom so that the one can be separated from the other. In the coal washer the rough coal from the screen falls into water in a tank or trough. Here it is churned up violently with the same result as before—the stone and dirt sink, the coal comes to the surface. The latter is washed over the edge with the escaping water whilst the former accumulates at the bottom of the tank and can be removed periodically.

Very small sizes used to be dumped on the waste heap as nobody wanted them. To-day very little of this waste goes on. The small coal is sometimes mixed with pitch and pressed into rounded blocks, or briquettes, which burn quite readily on domestic fires.

Rubbish is usually carried away by an aerial ropeway, an ingenious bit of machinery which uses little human labour. The tubs full of waste from screens and shaft are emptied down a shoot into large steel buckets. To the handle of each bucket is fixed a wheeled trolley which runs on a strong rope suspended from light steel towers. Above the handle stretches an arm with a clip by which it can be attached to a thinner moving rope which tows the bucket

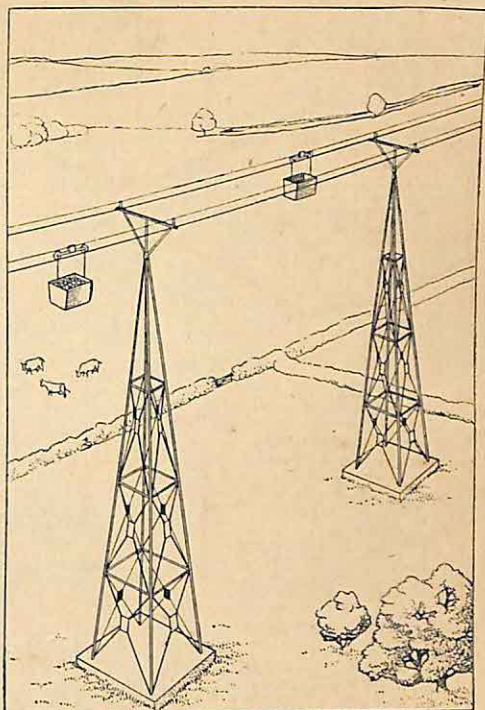
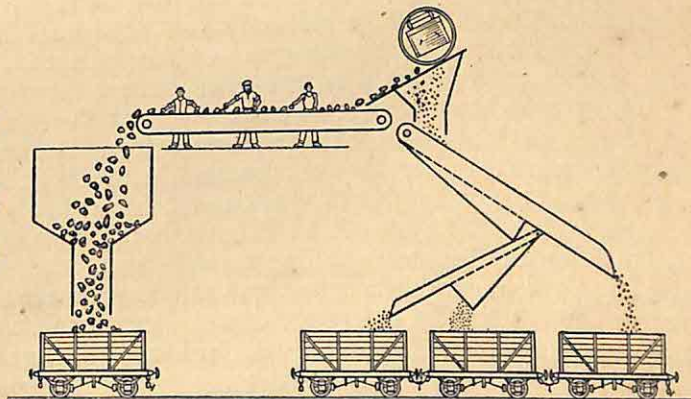


Fig. 101. Aerial ropeway carrying waste to the spoilbank and bringing back empty buckets.

along to the tipping place. On the framework over the heap a horizontal bar tips up the bucket as it passes and thus empties its contents on the spoilbank.

Fig. 102. Screening system. Coal from the tub in the tippler falls on the first screen. Large coal passes to the conveyor belt where waste is picked out by hand. Smaller coal is sorted by other screens into three different sizes.



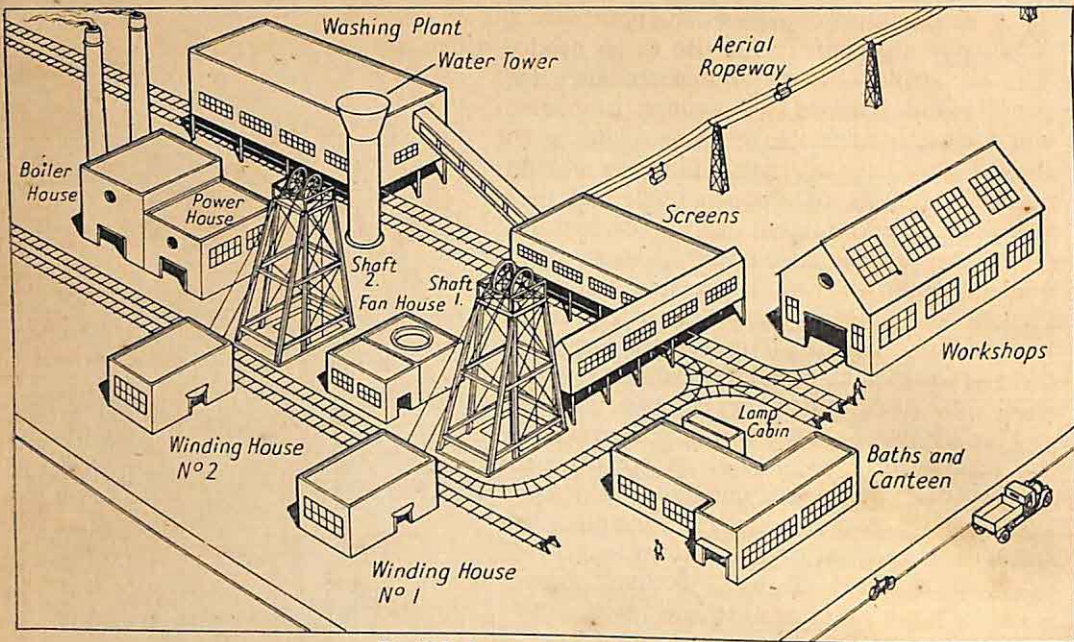


Fig. 103. Lay-out of a typical pit yard.

AROUND THE PIT YARD

IN British coalmines at least one in every five of the people employed works most of his time at the surface. The cluster of buildings round the shafts is as large as many big factories. A walk through the yard will give an idea of the main tasks carried on there.

Just within the entrance gates stand the offices. Since the selling of the coal and the purchasing of materials for a whole group of mines is managed through a central office in a nearby town these are not very extensive. There will be rooms for the manager and under-managers where they can discuss the running of the mine, plan the work and interview workers. The pay office will have a staff to deal with all matters affecting wages and a big light room will be given to the surveyor and his helpers. Here are drawn the careful plans which show all the working places and the elaborate ventilation, lighting and haulage systems. The training officer

will probably occupy another room and the transport officer will certainly have one, where records of coal won are kept and arrangements made for its dispatch. A first-aid room will have in constant readiness stretchers, bandages and rescue apparatus.

Modern mines are all equipped with baths and these will be found in another block near the gates. The miner on leaving the cage passes first to a room where his boots are cleaned and greased by machinery. He leaves these with his pit clothes in his locker in the next room, where he will find them dry and warm when next he comes to work. Armed with soap and towel he passes to the shower baths and, clean and refreshed, goes on to dress in his home-going clothes in the clean locker room. On his way to the baths he will have left his lamp and battery in the lamp cabin and these will be cleaned, tested and recharged ready for his next shift.

Storage spaces and buildings near at hand contain supplies of steel and timber, spare

parts for machines, explosives and new tools, all safely put away ready for use when needed. The mechanics—fitters and electricians, carpenters and blacksmiths—occupy a spacious and well-lighted block of shops close to the stores. Here they overhaul and repair all kinds of mine equipment, sharpen drills and picks and make new equipment that may be required. Often they will be called upon to work underground, doing repairs on the spot, extending haulage and lighting equipment as the coal is worked out. Much of their work has to be done at week-ends, in holiday periods or in the third shift when coalcutting is not going on.

The screening and washing plant takes up a good deal of space. The rubbish from the screens and washer is generally tipped on waste ground some distance from the pitmouth and with it goes rock from roadways and roof falls that cannot be disposed of underground.

Other large buildings are the boiler house and the power house with the furnaces and boilers which provide steam to drive the electricity-generating plant. In most of the older mines steam also drives the great winding engines that raise and lower the cages in the shaft. Close to the upcast shaft will be found the fan house. Because of the importance of always keeping a strong current of air moving through all the mine workings, the great fan usually has its own engine and often its own furnaces and boilers too. A low but very wide chimney carries away the foul air.

Railway tracks cross the yard in every direction—they seem almost as numerous as underground. Small steam locomotives are constantly on the move, shunting trucks to and from the screen hoppers and making up the loaded trucks into trains for dispatch. Narrow-gauge tracks lead from the shafts to the stores and repair shops so that tubs can be loaded with stuff needed underground and then run directly into the cages. There are few busier places than a pityard, or other places of the same size where men of so many trades are employed.

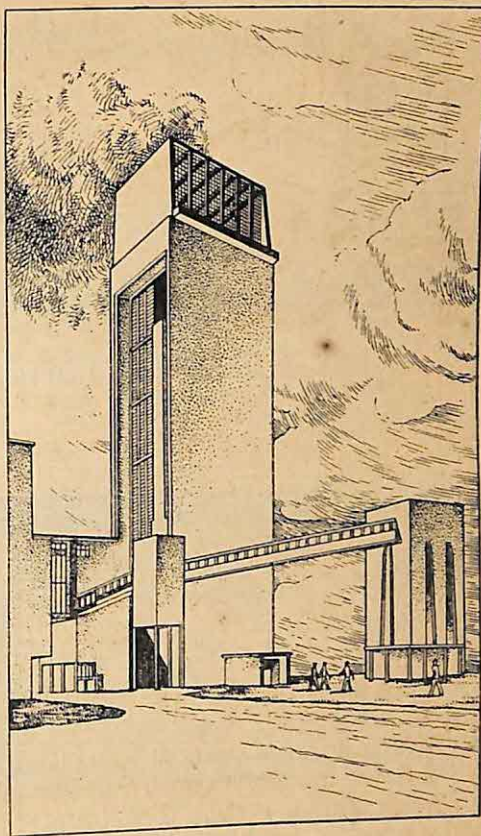


Fig. 104. A modern pithead.

In the new mines now being opened the appearance of the pityard will be very different. The towering steel framework supporting the great pulley wheels and the slanting gangway from pulley wheels to engine house will be absent. In their place will be seen a tall rectangular tower of brick or concrete, rising above the shaft. Here the winding engine, now electrically driven and controlled, will occupy the upper floor with its rope drum immediately below and both therefore situated directly over the shaft. The lower buildings on either side of the central tower will enclose the runways from shaft to screens and washing plant, with stores and workshops beneath at ground level.

BOB BECOMES A MINER

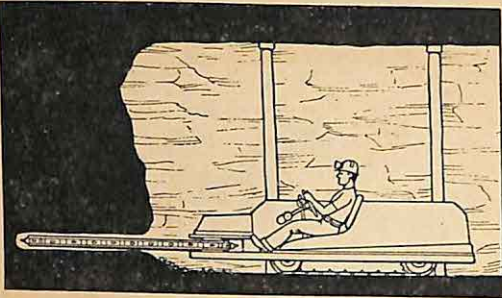


Fig. 105. The mechanical coal cutter undercuts the seam more quickly and to a greater depth than the hewer could reach.

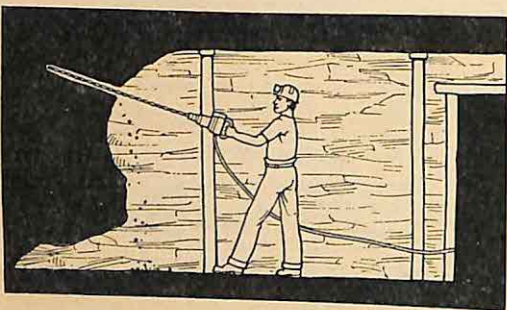


Fig. 106. The power drill driven by compressed air or electric power quickly penetrates to the depth required for the blasting charges.

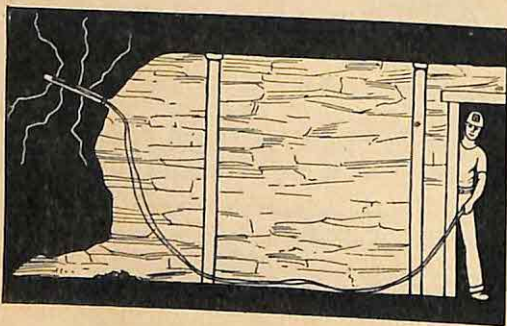


Fig. 107. The charges are now exploded electrically, after the shot-firer has taken shelter at a safe distance. Formerly this used to be done by lighting a slow-burning fuse.

AS we have seen, Bob Elliott's father was never taught to be a miner. Nobody worried very much whether the job was suited to his strength or was the kind of job he could do best. When Bob goes to work he will find things very different. He will be seen by the colliery doctor before he starts and will be told whether he is fit for a miner's life and whether he would be wiser to keep to surface working rather than to go underground. His eyesight for example might unfit him for work in badly lighted places or his lungs be liable to damage from dust.

Every mine has a training officer who looks after lads like Bob for quite a long time. No one nowadays is allowed to work below ground until he has had some weeks of training at the surface. During this time men who have themselves worked in the mine will teach him how the work of a mine is carried on. In this way he will learn what he must not do in the pit, and why. He will practise in daylight things he will afterwards have to do by the light of his lamp alone, such as the best way of getting back on the track a tub which has left it. Then he will go on to do these tasks in artificial tunnels, so that he may get used to working where the roof is low and as one of a team on bigger jobs. Some of his time will be spent in physical training to strengthen the muscles he will most frequently use in his work. Some of this training will take the form of games and some of exercises like those he did at school, except that he may find himself in a tug-of-war with a loaded tub instead of with an opposing team of boys, and in his arm and shoulder exercises find himself burdened with a pick or shovel. Trips to various parts of the mine, both above and below ground, will show him machinery at work and then in classroom and workshop he will help to take the same sort of machines to pieces and reassemble them, or be shown

how to replace worn or damaged parts. Only after six months of this training and surface work will he be allowed to start work underground. At that stage a talk with the training officer will help him to choose the particular kind of work he wants to do.

All that is only the preliminary training. When Bob begins work in the mine he will still have instruction. All the boys who want to work at the coal face will have another three months period during which they will go to a training face, chosen for its safety and easy conditions, where skilled and experienced miners will watch all they do and show them the safe and easy ways of doing their tasks. Thus Bob may spend a week on the cutter with the man in charge, a week at loading, another week with the timbering gang, and so on. Only then will he begin on the particular job he has chosen for his own. During the first three months at this he will always have a skilled man at his side.

If he is as interested in mining as he should be, he will want to change his job after a few months. The training officer will see he is changed over and again he will have someone at hand to help him till he knows the new task thoroughly. If, like most intelligent lads, he is interested in machinery and has shown he can handle tools he may be taken for a time into the repair shops where he will see the damage caused by careless handling, learn to avoid it and how to recognize when and why the machine is not working satisfactorily. Some mines now give certificates to fully trained men which enable them to get skilled work at the highest rates of pay in any mine needing their services.

The training officer is always on the lookout for skilful and careful young fellows, willing to work hard and interested in their work. Such men are sent for advanced training to special centres where they learn to handle the newest types of machine and qualify for work as charge hands. The best



Fig. 108. The loader shovels the loose broken coal on to the conveyor belt which carries it away to trucks in the main roadway.

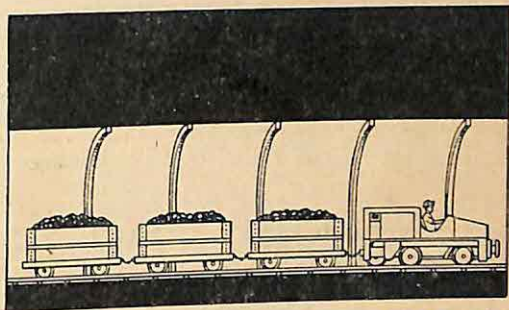


Fig. 109. The loaded steel trucks are drawn to the shaft bottom by diesel-engined locomotives.

men can go on to still more advanced courses which will fit them for posts as managers and under-managers or at least enable them to qualify as deputies or overmen.

If Bob chooses to take up underground work on the haulage system or roadways he will get the same sort of training for it. If, on the other hand, the mechanics' shop or the engine-room attracts him, he will probably be apprenticed and serve a period of years learning his trade of electrician or fitter or carpenter, beginning on the lighter and easier tasks and helping the experienced men till he can tackle all the varied jobs they do. Classes at the local technical school will give him the necessary theoretical knowledge.

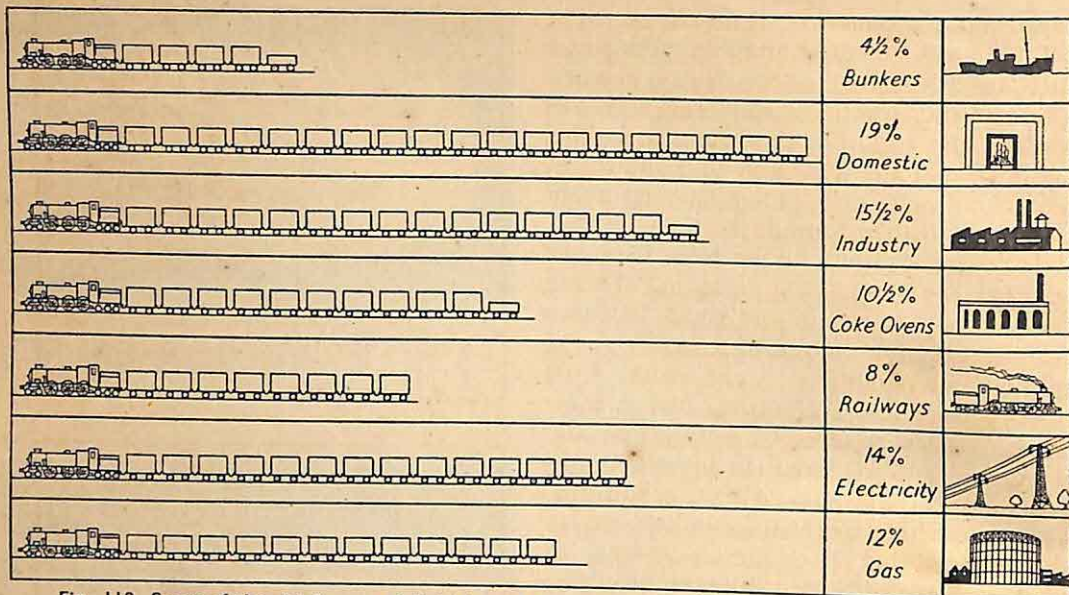


Fig. 110. Some of the chief users of British coal. The mines themselves use large quantities also.

WHO USES COAL?

IN 1947 two hundred million tons of coal were produced by British miners. Why do men dig this great weight of rock from the earth? The short answer is: "Because coal is the chief source from which we obtain heat." The heat of the sun of millions of years ago was imprisoned in the forest vegetation from which the coal seams were formed. To-day we can set free that heat by simply burning the coal. In winter we heat our homes with coal fires and cook our hot meals over them. In this way we use nearly one out of every five tons mined and about 150,000 men are employed to supply it.

Some one hundred and fifty years ago gas obtained by heating coal began to be used for lighting factories. Soon streets and then homes were lit in the same way, and nearly every village and town had its gasworks. To-day coal gas is mainly used for heating and cooking. The gasworks use one-eighth

of the coal produced in Britain. The coke remaining after the gas has been driven off is mainly used in the warming of large buildings such as schools and theatres.

The invention of the steam engine two hundred years ago provided a means of converting the heat of coal into energy which could be used to drive machinery. It was this which led to the rapid growth of coalmining, and to-day more than two-fifths of British coal is consumed in boiler furnaces. Engineering shops and factories of all kinds depend on steam power. The foods we eat, the clothes we wear, the books we read, the bricks for our buildings, the tools with which we work and the beds in which we sleep, all have called for the use of steam-driven machinery and thus for coal.

Transport is still mainly done by coal-heated engines. Steam locomotives draw most trains and steam engines drive most ships. Some trains and factories use electric power of course, but this is only another way

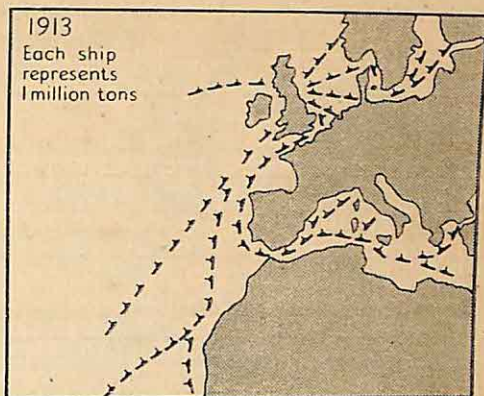
of applying coal and the steam-engine. The great dynamos or generators in the power station are driven by coal-fired steam engines. Because of the cleanliness and convenience of electricity the great power stations are called upon for bigger supplies every year and therefore demand more coal. They now use about one-seventh of British production.

The smelting of ores to get from them the metal they contain, and the reheating of these metals as they are made into goods and into machines, calls for the use of furnaces giving very high temperatures. Coke made from special types of coal is the usual fuel in these furnaces, especially those extracting iron and making steel, and so more than 20 million tons of coal each year in Britain go to the coke ovens.

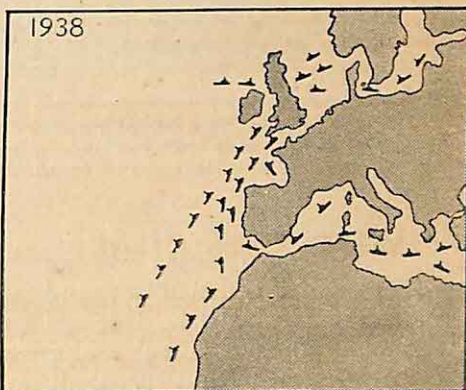
Countries without, or with very little, coal of their own need fuel for all these purposes. In the past Britain was their greatest supplier and they were glad to send us meat and wheat, raw cotton and wool, and a host of other things in exchange for it. Recently this export of coal almost stopped but it is beginning again and will become very valuable once more.



Fig. 111. The chief coal-producing countries.



(a) When the export trade was at its height.



(b) The decreased export between the two wars.



(c) The almost complete stoppage immediately after the second war. In 1948 ten million tons were exported.

Fig. 112. British coal exports. The diagrams show the fall in exports from 1913 onwards. They have increased considerably since 1947 but are still far below pre-war level.

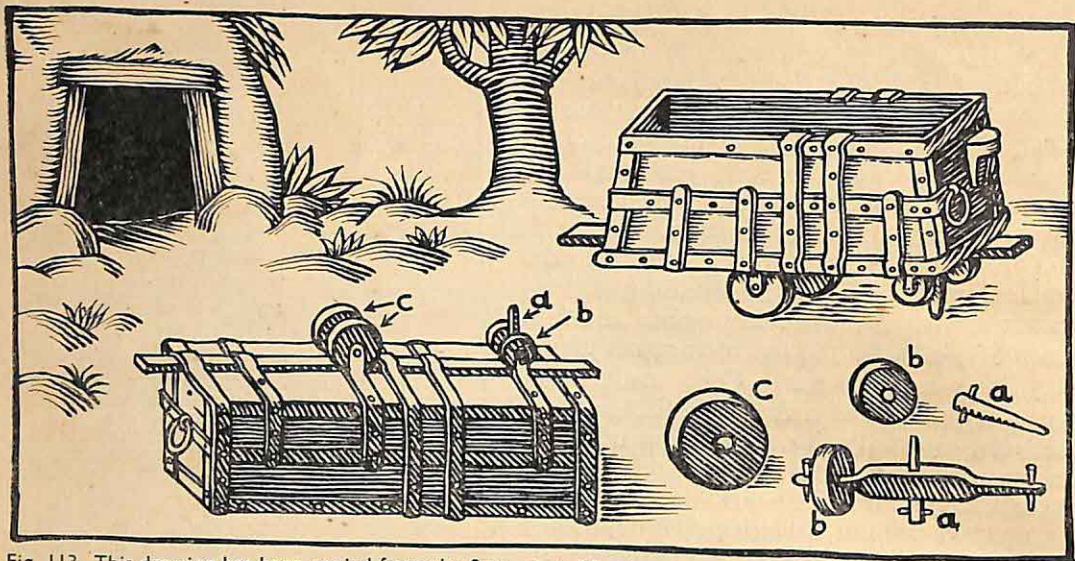


Fig. 113. This drawing has been copied from the first printed book on mining. It shows the construction of the tubs then in use in drift working. In low underground workings like the one shown coal was often carried in baskets slung across the workers' shoulders until about 150 years ago.

1 The drawing of tubs for mine use was copied from a book printed over 300 years ago. The track consisted of two planks set a couple of inches apart so that the small wheels ran on the planks and the peg stuck down between them, thus keeping them on the track. The bigger wheels ran on the earth.

Make a drawing or drawings to show how modern tubs are kept on the rails.

2 In what ways has a miner's wife a more difficult life than the wife of a carpenter, a factory hand or a shipyard worker? How do pithead baths and canteens help her?

3 The mine tips or spoilbanks are ugly and create a lot of dust. Can you suggest any ways of getting rid of them?

4 There are jobs at the mine for Bob Elliott from the day he leaves school, for his older brothers and for his father till he is too old to work. Name suitable jobs for boys, for youths, for younger men and for older men.

5 What work about the mine is suitable for: (i) the youth who is strong but not very good at lessons; (ii) the grammar school boy who is keen on science and mathematics; (iii) the boy who likes messing about with machinery; (iv) the boy who is good at writing and at figures; (v) the boy who is handy with tools?

6 What jobs are there in the mining village for Bob's sisters? The father of his friend Bill was killed in a mine accident. What work can Bill's mother get to help in bringing up her children? Would she have found it easier if she had lived in a factory town?

7 The twenty-four hour clocks in Figure 114 show the working hours, sleeping hours and leisure hours of two miners on different shifts. Make similar diagrams for your day and for your father's day. If the miner has a hot meal before going to work and another on returning home, on which of the two shifts will his wife prefer him to work?

8 The miner's week is now five days yet many workers at the colliery are still employed on Saturdays and Sundays. Name some of these workers and tell what they do on these days?

9 Figure 115 shows a simple apparatus, made from cotton reels, by means of which wire or string can be twisted to form a thicker cable or cord. Explain how it works. Make a similar model for yourself and see if you can improve on the pattern.

10 Figure 116 shows the numbers of men employed at the coal face, at other jobs underground and at the surface in British mines in 1944. Who are the chief workers included in each group?

11 In the old mining districts one often finds buildings with crooked walls and leaning chimneys, houses whose walls are held together by steel rods or bars, and roads that have often to be levelled again. Why is this?

12 Norway, Italy, Ireland, and Argentina all need to import coal for their railways and gas-works, and have generally obtained it from Britain. Which British coalfield is in the best position to export to each of these countries? What useful cargoes can be brought from each in return for the coal sent to them?

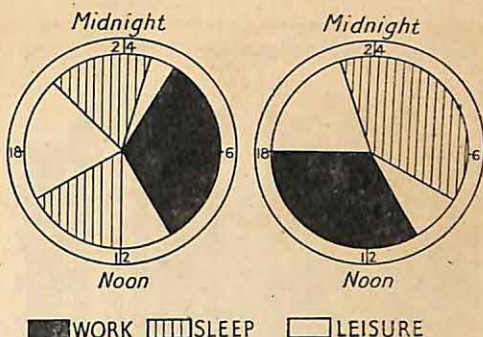


Fig. 114. Two ways in which the miner's day may be divided.

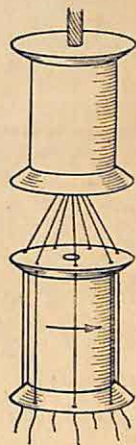
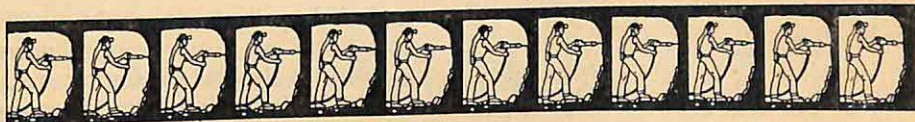


Fig. 115. A simple model of how wire ropes are made.

Workers
at
Coal Face



Other
Underground
Workers



Workers
at
Surface



Fig. 116. British miners. Each figure represents 25,000 men.

GAS AND COKE

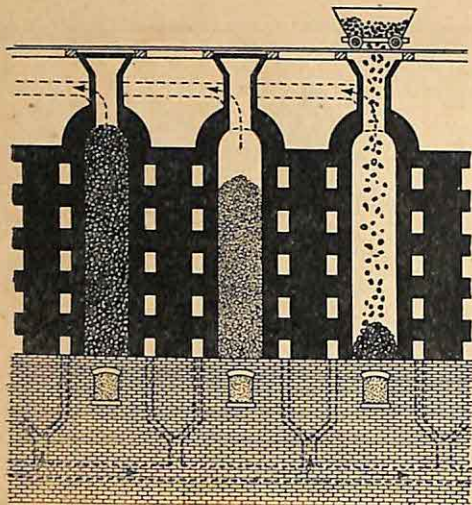


Fig. 117. Section of three coke ovens. The first is freshly loaded, in the second the coal has been partly converted into coke and the third is being loaded.

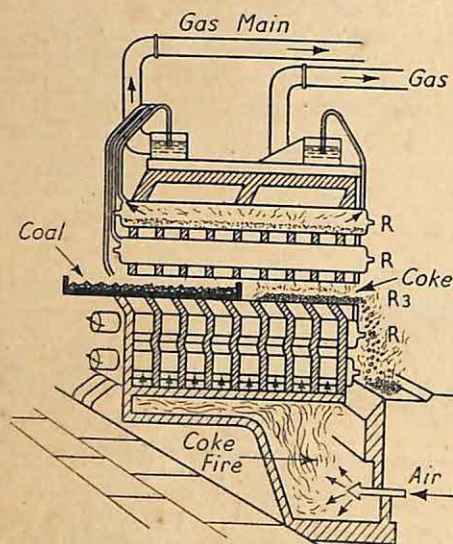


Fig. 118. A battery of five gas retorts (R). The middle retort is being recharged. The rammer is pushing out the old charge, now changed to coke. When rotated and withdrawn it will leave the new charge in place.

A VERY great variety of things are now made from coal. The starting point in their manufacture is the distillation or roasting of coal, that is, the heating of coal in a closed space without sufficient air for it to catch fire and burn. One hundred and fifty years ago a Yorkshire clergyman described what happened when he did this. "At first there came over only Phlegm, afterwards a black Oil and then likewise a Spirit arose." The phlegm, oil and spirit of the worthy vicar are now known as ammoniacal liquor (mainly oily water smelling strongly of ammonia), coal tar and coal gas. The substance remaining is coke, in many ways a more valuable fuel than raw coal. Coal distillation is carried on to-day in gasworks, where the main object is the gas driven off, and in coke ovens, where the main product is the coke remaining. In both cases all the other products are now carefully collected and passed on to the chemical works.

In a modern cokeworks the crushed and washed coal from the nearby mine is heated in firebrick chambers, built side by side to form a battery. These ovens are perhaps thirty feet long, seven or eight feet high and about two feet wide. Each end is closed by a sliding door made of firebricks fitted in a steel frame. Passages or flues run through the walls between the ovens and it is a mixture of coal gas and air burning in these flues which heats the ovens and roasts the coal they contain. Coal is fed into the oven from an overhead tubway until it is almost full. The charging hole is then closed and both it and the doors sealed up with clay. As the charge is heated from the red-hot walls the gas and liquors are given off and pass through other flues towards the chimney stack. On their way they are cooled, thus trapping the tar, and passed through water to take out the ammonia and some of the impurities of the gas. The gas is led back to the wall flues and burned to roast the charge in another oven. Only the fumes from this burning gas reach the

chimney. When the coal in an oven ceases to give off gas it is drawn or emptied. The clay is broken away from the doors and both are opened. The glowing mass of hot coke is pushed out by a long steel ram and falls on a sloping bench where it is sprayed with water until it is cool enough to be loaded and sent off for use in the iron and steel works. This kind of coke will not burn easily in open firegrates.

In some ways a gasworks is run the other way round to a cokeworks. When coke is wanted the gas that might be wasted is used to roast the coal, whilst in a gasworks where gas is wanted some of the coke that might be wasted is used to roast the coal. You always get gas and coke together; you cannot have one without the other. Cokeworks have gas to spare and gasworks can sell coke. The coal from which gas is to be made is heated in long cylindrical tunnels or retorts, sometimes placed horizontally and sometimes vertically. These are arranged in stacks with spaces between and are heated by burning gas produced by blowing air and steam through a coke fire. Pipes lead off from each end of the retort to a wide pipe or main which carries the gas to the purifiers and then to the gasholders. On the way the tar and ammonia and other impurities are separated and carefully collected to be sent to the chemical works. Turn over to find out what happens to these substances there.



(b) The sick man's medicine.



(c) The ladies' stockings.

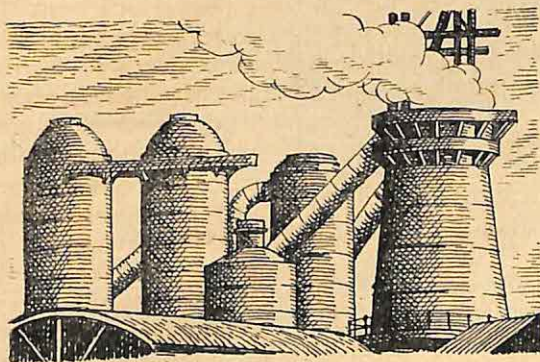
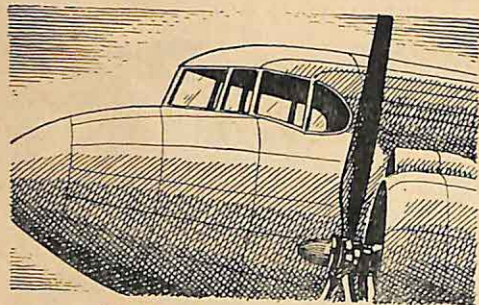


Fig. 119. Things made from coal:
(a) Fuel for the blast furnace.



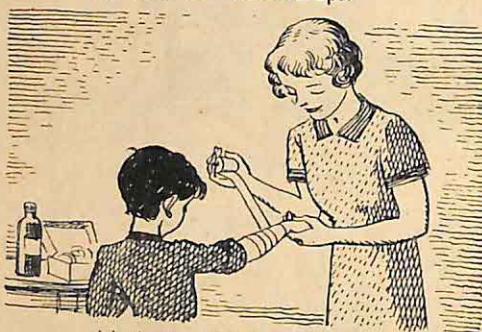
(d) The preservative for the garden fence.



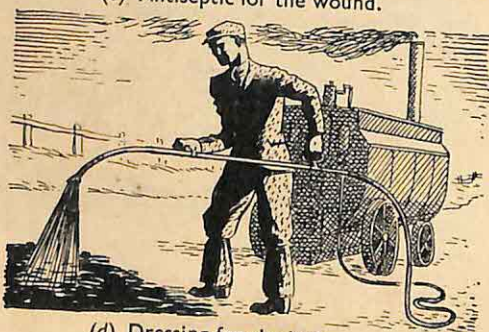
(a) The cabin windows.



(b) Fertilizer for the crops.



(c) Antiseptic for the wound.



(d) Dressing for the highway.

MORE THINGS FROM COAL

IN each of the twelve drawings on the previous page and on these two pages there is shown in use something which has been made from coal, and these are only a few of such things. How many can you discover? There are so many of them and of such different kinds that this section might almost be headed "What would you like?" It is many years now since one of our weekly journals printed this verse:

*"Oil and ointment, wax and wine,
And the lovely colours called aniline:
You can make anything, from a salve to a star,
(If you only know how) from black coal tar."*

The list now is a much longer one, though they are not now all obtained solely from the tar.

The by-products of the coke ovens, *i.e.* all the substances other than coke which they produce, are dispatched to chemical works for treatment. To these are added those obtained from gasworks. Sometimes the ammonia liquor is treated on the spot, for by passing the ammonia into sulphuric acid the well-known fertilizer, ammonium sulphate is produced. This is used in large quantities by farmers and gardeners because it adds nitrogen to the soil thus encouraging the growth of all green crops.

The coal tar is perhaps the most useful of all the by-products for it is easily split up into a number of useful substances by further distillation. One of these is the creosote used to protect wooden railway sleepers and fencing against decay. Benzol, useful as a substitute for petrol, is another. The tar oil used by the fruit-grower in winter to kill insect pests and the bitumen and pitch used by the roadmaker and the layer of electric cables are also obtained from the tar without much trouble.

It is however when the chemist gets busy with the tar and liquor that the marvels begin. In 1856 an English chemist prepared a blue dye from tar. This was the first aniline dye. Since

Fig. 120. More things made from coal.

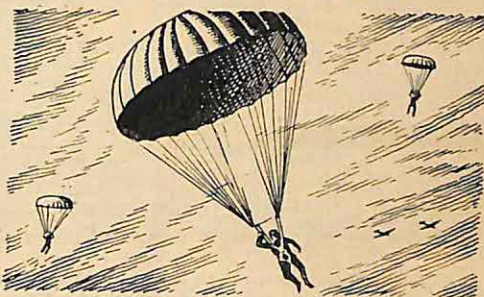
then many thousands have been made and fresh colours are added every year. Nearly all the coloured materials we wear or use in our homes, the coloured inks and paints used in printing and decorating, owe their colours to dyes made in this way. Many of the drugs used by doctor and dentist are built up by the chemist from substances he obtains from the treatment of tar. The tablets taken to cure a headache and the medicine to cure a cold or fever, the disinfectant washed over a wound or sprayed in the air to kill germs or the insects that might carry them, the drugs injected by dentist and surgeon to lessen or remove pain, those used to protect men working in the jungle against disease and insect bite—all these and many others are derived from the waste of gasworks and coke ovens. You may know the names of some of these things, such as aspirin, cocaine, camphor and DDT. The photographer uses other products drawn by the chemist from the same source. Most of the developers which bring out the picture on the exposed film are of this kind. The sweetening substance known as saccharin, so much used as a substitute for sugar in recent years, is another of his products. Even fine perfumes can be obtained from the same unlikely-looking source.

Many explosives are built up like the dyes and from the same raw materials. The TNT made in great quantities during the war for use in shells and bombs is well known. Engineers use many other types for blasting work in mines and quarries and tunnels.

In some ways the most interesting of the strange new products are those grouped together as plastics. Nylon is one of these. It is a kind of artificial silk which is stronger in every way than real silk. Its manufacture is very complicated and the product is therefore still somewhat costly. It can be woven like real silk into dress materials and furnishing fabrics or into women's stockings. Some of the plastics start from coal instead of from the tar only.



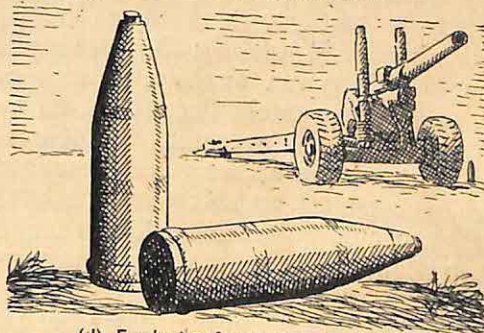
(a) Sweetening for the cup of tea.



(b) Fabric and cords for the parachute.



(c) Insect killer for the orchard.



(d) Explosive for the shells.

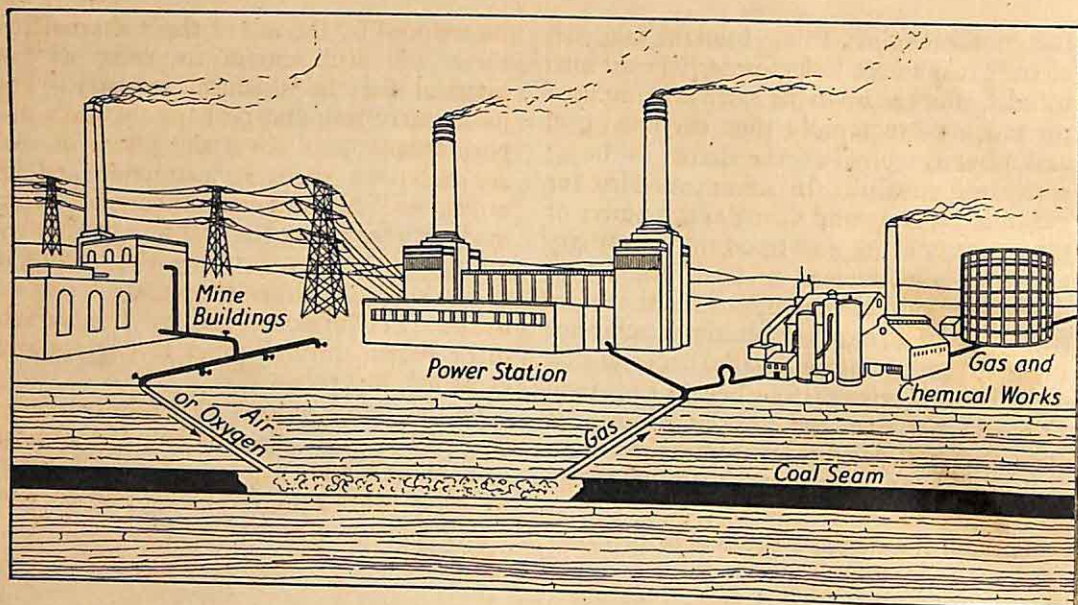


Fig. 122. The coal mine of the future? No shafts, no cages, no underground workers. The coal seam has been converted into a kind of natural coke oven or gasworks and the remaining coke burned. The gases thus produced are drawn off to the power station and chemical works. All this is still a dream, but the first experiments have already been made.

THE FUTURE OF COAL

SINCE coal is being dug from the earth at a great rate and is daily destroyed in millions of fires, the time when there will be no more available can be foreseen. That end will not be for many years yet, for there are some countries, such as China, where much is known to exist and but little has been worked. But what of the lands where it has long been mined in great quantities, and what of British supplies? For how long can we hope to draw coal at our present rate? That is not an easy question to answer accurately. There may be coalfields yet undiscovered, though the geologist can tell us that even if that is so they must be quite small. There may be deep seams unreached by our present mines. More important still, men may find cheap ways of working seams so thin that they

are not worth the cost of doing so to-day. The introduction of open-cast methods has thus made available many millions of tons of coal that were thought to be too difficult and costly to mine for their working to be worth while. But even with present methods at present rates of working Britain can be sure of securing enough to last us for another five hundred years. Some of our coalfields will certainly not last so long and parts of most are already worked out; nevertheless, we are not likely to be without coal for the getting for some hundreds of years to come. New uses for coal may be discovered of course and thus lead to increased demand for it. These do not seem likely, however, to do more than make up for fresh economies in our present-day ways of using it.

Other sources of heat and energy may replace it of course. Some ships and steam engines now burn oil instead of coal, and

the motor engine, using mineral oils, has already taken over tasks formerly performed by coal. But the oil in the earth is being used up much more rapidly than even the coal and already some of the latter is being converted into oil. In some countries, for example Norway and Canada, the power of the rivers is being converted into electricity and thus used instead of coal, but not all lands have suitable conditions for this to be possible. In Britain we certainly could not satisfy a tenth of our industrial needs in that way. Atomic power is another possible rival to coal. No one can say how soon, if ever, energy derived from splitting the atom will provide an alternative source of energy to coal and oil.

Though the demand for coal as fuel may

be reduced by the use of these alternatives, there will still remain its value as raw material for the chemical industry. The most interesting and perhaps the most important questions about the future of coal are questions about its extraction and its utilization. Already experiments are being made in converting the coal into gas underground, without ever cutting it or hauling it to the surface. Other people are trying to use powdered or pulverized coal, fine enough to be blown through pipes to engines and exploded, like petrol.

Of two things at least we can be certain—coal will keep its place as one of the most valuable of Nature's gifts, and it will be used in many ways and for many purposes at which we can only guess as yet.

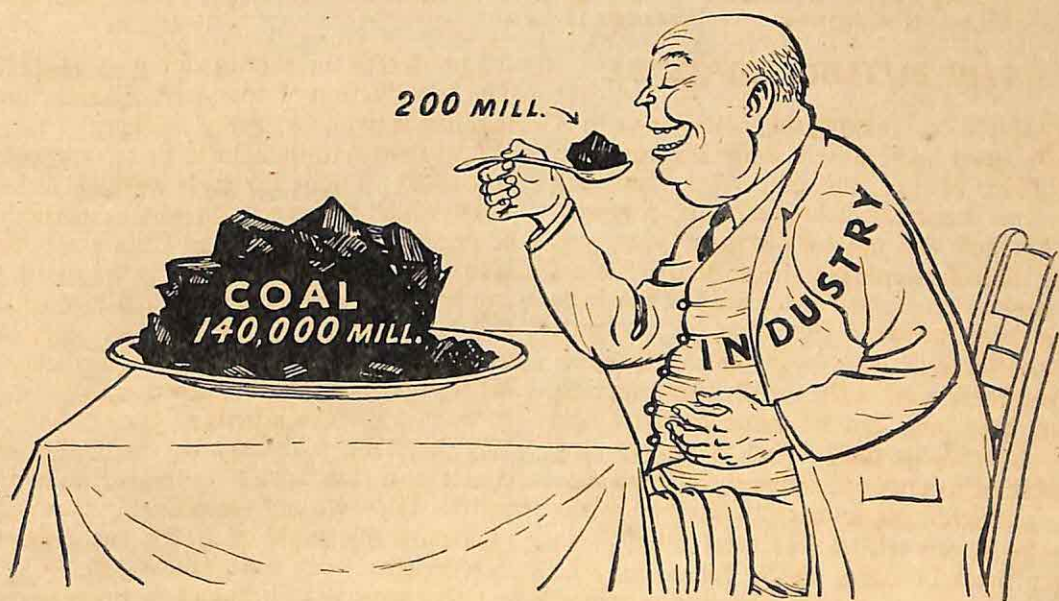


Fig. 123. How long will Britain's coal supply last? At least 140,000 million tons lie below the surface. At present we use about 200 million tons a year. Did the cartoonist forget anything when he wrote INDUSTRY?

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MEN AT WORK

